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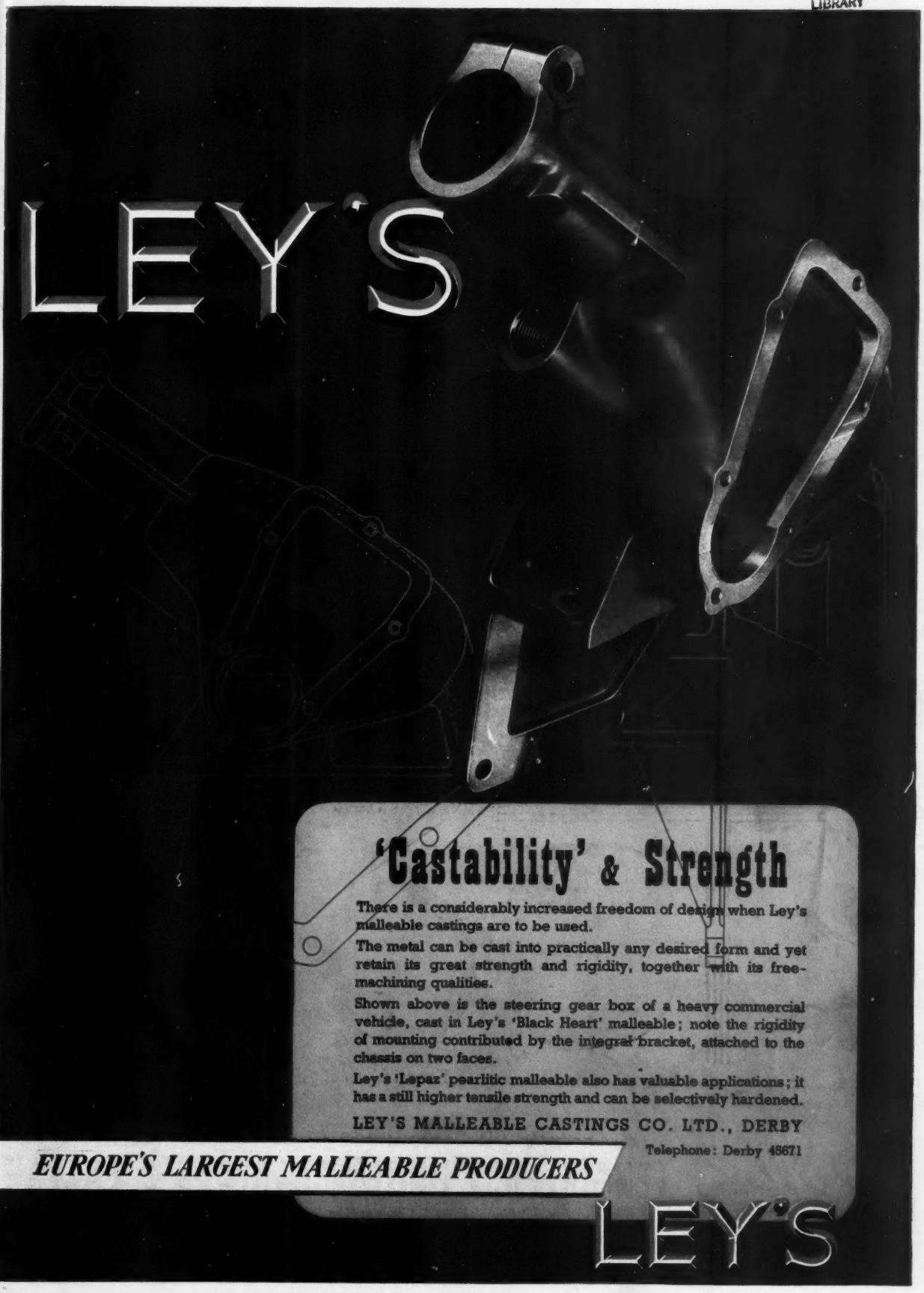

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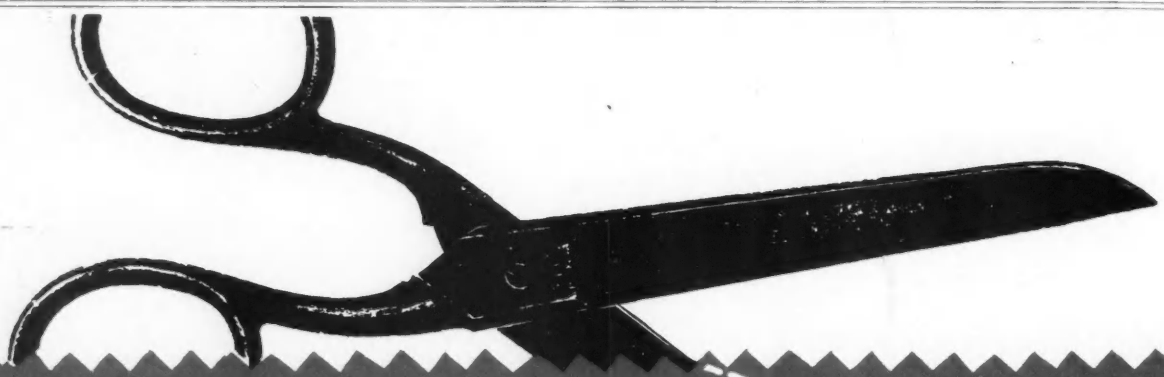

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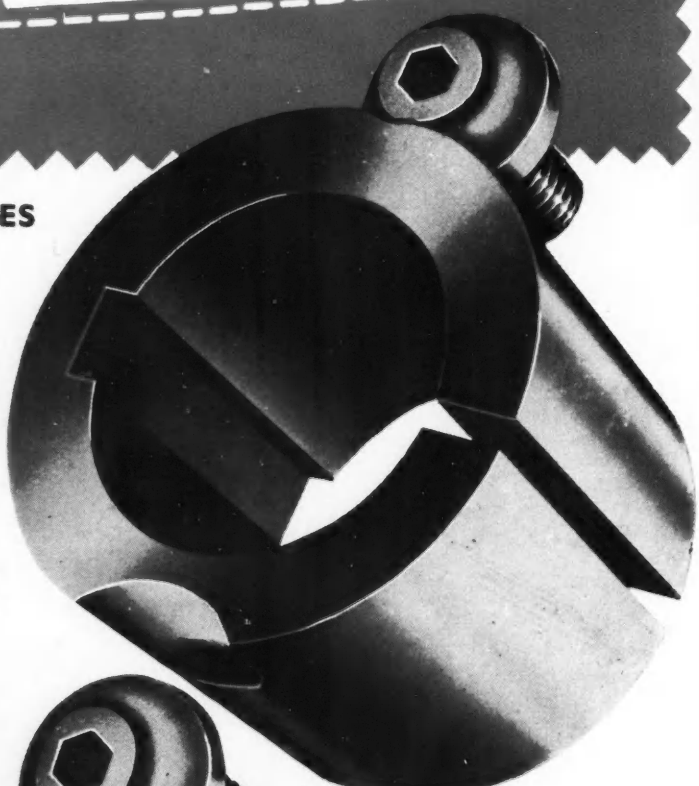

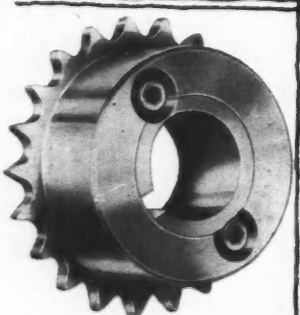

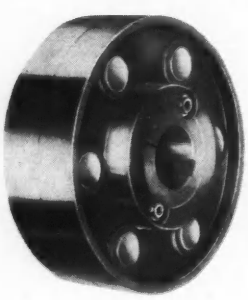

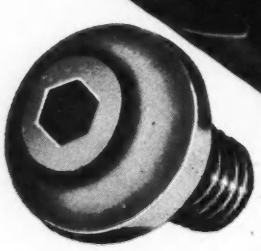

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THE ENGINEER

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RAILWAY SIGNALLING PROSPECTS

The plan for the modernisation of British Railways is progressing to the extent that large contracts have been placed, that a host of schemes are in process of being worked out, and that much experimental running is going on with new locomotives and railcars. The scale of the work will eventually be very large and the cost even more so. Apart from the allocation of major contracts, and all that it will involve in the way of production problems for the manufacturers concerned, much attention is now being given in railway workshops to the layout of facilities for repair and maintenance of the new equipment. While not seeking to minimise either the scale or the importance of these tasks, they do represent clearly-defined jobs to be done. Granted there will be all the problems of a rapidly expanding industry, the selection of men for training in leadership, recruiting of staff, the delegating of responsibility, with the exercise of that judicious blend of courage, tact and discretion that the keeping of good human relations needs in such fluid circumstances. But apart from all these clear-cut engineering tasks, there is the overriding question of traffic control. Since the publication of details of the plan we have many times emphasised the need to aim for much higher standards of punctuality, and we have published articles analysing present-day running conditions that show that the form of motive power is very far from being the predominant factor in the failures to maintain booked time which are so prevalent to-day. Punctuality is the outcome of a close co-ordination between a number of railway departments, and of working in which the attitude of mind of individuals can more than outweigh the advantages, or disadvantages, of any particular machine. Anything that can be done to bring the departments concerned into closer co-operation, or to cut out operations that can be prejudiced by the whim, fancy, thoughtlessness, or lack of judgment of individual operators is worth the most earnest consideration. But the problem is more involved than the mere solving of a single engineering task.

In view of this urgent need to improve the control and regulation of traffic, a paper presented to the Institution of Railway Signal Engineers on December 7, 1956, by Mr. O. S. Nock, " Power Interlockings—Past History and Future Prospects," makes an interesting forecast about possible developments in the future. The author began by tracing the gradual evolution of the power interlocking machine, and the contemporary development of the practice of traffic control. At first they were quite unconnected. Signal engineers introduced various forms of power, compressed air, hydraulic, electric, for reducing the manual work required to move points and semaphore signals ; traffic officers sponsored the installation of an elaborate telephone network for reporting the movement of trains, volume of traffic on hand, and the locomotive and rolling stock position. The coming of the track circuit paved the way for the earliest liaison between the two techniques of signalling, and control ; the track circuit made practicable the illuminated diagram, which in turn made it no longer necessary for a signalman actually to *see* all the trains. The area under control of one box could be greatly extended, and extension of signalling control at once meant better regulation of the traffic. Mr. Nock quoted, in particular, the case of York, where, within the orbit of a very large signalling concentration, there had been included the remote control of the entrance and exit of one of the largest motive power depots in the country, where the number of engine movements per day rises at times of peak traffic to 270 in and 270 out. By the older standards of signalling technique the regulation of movements at such a yard outlet would be regarded as a major responsibility in itself ; but at York, remotely controlled from the signalbox in the centre of the station, it is merely one of the many facets of operation regulated from the one control panel.

The improvement in working has been really spectacular, and it was on the basis of such experience that Mr. Nock ventured to look into the future. Ideally there would seem to be great advantages in combining the tasks of signalman and controller, for while control is concerned as much with the provision of motive power and stock as with running the trains, the section controllers at many district offices are for the most part a species of super-regulators of traffic. If illuminated diagrams could be provided covering the entire operating sections, and control could *see* the precise whereabout of the trains, instead of having to depend upon telephone reports from signalboxes which have to be recorded on sheets or graphs, its effectiveness would be greatly increased. Put another way : if the area of full signalling control could be expanded to an entire district, one is very near to the ideal state of complete co-ordination. Until recently, however, the practical objections to remote control on so extensive a scale have been overwhelming. The cost of cable would be altogether prohibitive if such a scheme were planned with direct wire control for

every function, and the coded remote control systems known generally as Centralised Traffic Control, or C.T.C., would restrict the number of trains that could be handled from any one centre due to the time taken for the control codes to be sent out, and for the indication codes to come in. But now, the availability of electronic methods has made it possible to send thirty control codes and to receive sixty indication codes per second, so that the areas that can be signalled or regulated from one panel are no longer constrained by geography or density of traffic. With the spectacular results of York in mind the signalling of the future can be visualised as a series of large concentrations, based on the more important traffic centres, as at York, with the connecting lines between them remotely controlled from the large centres. By such means it should be possible to exercise efficient regulation over a wide area surrounding each centre, and we are sanguine enough to believe that punctuality would be greatly improved thereby, whatever form of motive power was employed.

HEAVY-OIL ENGINE WORKING COSTS AND PERFORMANCE

The "Report on Heavy-Oil Engine Working Costs and Performance," presented at a general meeting on December 20, 1956, of the Diesel Engineers and Users Association, has been issued at a time when altogether exceptional interest is focused on the subject dealt with. The report relates to the year 1955 and includes details of the working costs and performances of internal combustion engine plant at a total of 100 stations. No one studying it will fail to register indebtedness both to the committee responsible for its compilation and to the members of the Association contributing the returns on which the report is based. In addition to thirty-one returns from British electricity generating stations operated by public supply authorities, nine returns are from industrial users, three from large retail stores, three from waterworks generating their own electricity, one from a film studio and one from a sewage disposal works using methane generated from sewage. While the report was compiled prior to the events which have produced the existing dislocation and uncertainty about both the supply and the cost of fuel oil, it contains a sentence of high significance in this connection: "Having regard to the increasing cost and scarcity of fuel generally, the use of waste heat wherever possible should, we consider, be thoroughly investigated." Readers of the report will examine with particular interest those "Notes and Comments" which, received from members, contain references to the utilisation of heat otherwise wasted.

There must be many among us who agree with the eighteenth century poet in his declaration that: "Experience joined with common sense to mortals is a providence." It is certainly a providence to those mortals who, being users of heavy-oil engines, are likely to measure the suitability of the plant selected by the success of the engine builder in the design and construction of the engine. Throughout upwards of four pages of "Notes and Comments Received from Members," the report gives details of all sorts of experiences with many types of engines, including a 2200kW gas turbine. From such an aggregate of installations a great deal of guidance can be gleaned and one deduction certain to be reached is that whatever may be the relative merits of the engine, much depends upon the standard of operation and maintenance and the adequacy of the installation accessories. The report is not lacking in hints as to the value of expenditure on preventive maintenance and we find emphasis on caution—or conservatism—in design as a means for avoiding breakdown of machinery. Marine oil-engine builders, as well as shipowners, will have noted a paragraph in the Presidential Address recently delivered before the Institution of Mechanical Engineers, wherein Mr. T. A. Crowe, referring, *inter alia*, to the propelling machinery of the "Queen Mary," remarks that "The conservatism shown in the original design of this machinery has been amply proved because the 'Queen Mary' has been in service for more than twenty years, including a very strenuous wartime service, and has steamed approximately 2,300,000 miles. The teeth of the main gearing show no sign of wear and only minor repairs have been necessary to other parts of the machinery. The ship has never missed either sailing or arriving on schedule owing to a machinery defect." Praiseworthy, indeed, is the conservatism which can contribute to a performance so outstanding, and the more successful marine oil engines are likely to be those in which the main target of the designer has been operational security, a factor that does not necessarily conflict with advanced design. It will be found, moreover, that with other things equal, availability is tied up with maintenance, the importance of which—whether on land or on sea—cannot be too strongly stressed.

Reference has already been made to the recommendation, in the "Report on Heavy-Oil Engine Working Costs," about the recovery, wherever possible, of what is called "waste" heat. Since the report was drawn up the oil supply situation has been greatly changed by the Suez affair and certainly the history of the past few weeks cannot be without powerful effects on the future. Whatever the problems relating to the supply of the oil there must be a call for the unstinted efforts of all users of power and heat, efforts directed, among other things, to the elimination of waste. As long ago as 1907 tests made on a 300 b.h.p. four-cycle diesel engine specially equipped for the utilisation of the heat in the exhaust gases and jacket discharge water disclosed an overall thermal efficiency of about 80 per cent. Fifty years later the inducement to save heat has become more truly imperative and engine users in all categories will take note of the fact that out of forty-nine returns from plants in Great Britain, the 1955 Working Costs Report refers to eight in which use is made of the so-called waste heat. It is surely one of the good things belonging to adversity that it is apt to act like a catalyst on human intelligence and human efforts. May it prove true of the reactions of all power and heat users to the difficult situation which faces us to-day.

The Engineer
100 Years Ago
(DECEMBER 26, 1856)

"TO OUR READERS"

"A year has passed away since the first number of THE ENGINEER was presented to the world and we cannot refrain from availing ourselves of the opportunity sincerely to thank our friends for the cheerful and very liberal support with which they have favoured us. We accept it as a token of the still heartier goodwill with which we may hope our increased efforts will be accepted and rewarded.

"We are concluding arrangements with contributors of the highest eminence in their respective departments, alike of science as of engineering, to several branches of which we have hitherto been compelled to pay too little attention. Besides the civil branch of the profession, and the gas and water, there is also one branch which has been comparatively ignored, but which is, nevertheless, of the last importance, bound up, in fact, with the welfare of our country—we allude to *agricultural* engineering. We hold that the talents of the engineer can be applied as profitably to the land as to the road, to the plough as to the locomotive, and that it is not less absolutely necessary on the one side than on the other. It is no business of ours to show how stock is to be fattened at least cost, or where the best markets are to be found, any more than to dictate the rate of toll for carrying cattle on the lines, or to suggest the best system for controlling the share register, or of estimating the half-yearly dividend; but it fairly falls within the function of the engineer, civil and mechanical, to drain the land, improve the soils, provide the implements, teach how all-potent steam may displace the sluggish horse, aye, and, if needs be, and the spirit be willing, explain to our astonished rustics the economy of superheating, and the wonderful phenomena of wire-drawing. . . . We have no reason to doubt that even those of our readers who, like Vice-Chancellor Kindersley, may boast they never had a rood of land in their lives, may be not only interested but instructed by the dissertations which shall appear in our columns. There is not one of us, be he whom he may, who has not, directly or indirectly, a stake in the soil, and an individual interest in its culture and improvement."

A Seven Day Journal

Wood Engravings

ON page 925 of this issue, we conclude the series of reproductions of woodcuts from early numbers of THE ENGINEER, which have been published almost every week since January 20. In our Centenary Number, issued on January 4, 1956, some of these reproductions of wood engravings were included; the interest shown in them led us to continue the reproductions in succeeding issues throughout this year in which we have celebrated our centenary. The engravings reproduced are a representative selection from those used to illustrate this journal during its first twenty-five years of publication. The task of selection, fascinating as it has been, has not been easy—there are so many more which we would have liked to include. In making our choice, we have endeavoured to keep in mind the technical interest of the subject and also the artistic merits of the engravings. But our effort has been more than rewarded by the interest in the matter which so many of our readers have been good enough to express.

Calibration of Secondary Standards of Light

As part of its work on standards of measurement, the Light Division of the National Physical Laboratory, Teddington, has recently carried out a fresh comparison of its secondary standard lamps with the internationally agreed primary standard light source. Secondary standards held by the Light Division are special tungsten-filament vacuum lamps in terms of whose intensity the practical unit of light is maintained in this country year after year. The international standard is a small ceramic tube, or cavity radiator, immersed in a crucible full of pure platinum. The metal is first melted and then slowly cooled. During the short period while solidification is taking place the temperature remains stationary at the freezing point of platinum. At this temperature, at which the observations are made, the inside of the small radiator has, by definition, a brightness (luminance) of 60 candelas per square centimetre. In making the recent comparisons upwards of 100 "melts and freezes," obtained with the aid of a modern high-frequency induction furnace, were used to amass sufficient observations, which were made by precise photoelectric methods. It should be appreciated that because of the war no such comparison had been made since the occasion, about twenty years ago, when the N.P.L. lamps were first calibrated in this way. Nevertheless, the values recently found for the intensity of the lamps agree, to within one-half of 1 per cent, with the previous ones. We learn that no adjustment is at present envisaged in N.P.L. photometric standards or calibrations. However, a comparison with other countries' results is in progress at the International Bureau of Weights and Measures.

Coal Preparation Plant in South Wales

THE National Coal Board has now put into operation a new coal preparation plant at Cwm Colliery, South Wales. It is the 200th plant of its kind to be installed by the Board. Over the last ten years, the Board states, preparation plants, capable of treating 68,000,000 tons of coal a year, together with 107 froth flotation plants for cleaning coal in very fine form, have been installed at a cost of about £40,000,000. In addition, more than forty plants, with a capacity of 26,000,000 tons a year and costing nearly £19,000,000, are under construction or are being designed. The whole of the raw coal output from Cwm Colliery will be cleaned by the Chance sand flotation process for coal down to $\frac{1}{16}$in in size and the Fraser and Chalmers "mineral separation" froth flotation process for the remaining minus $\frac{1}{16}$in fraction. For this reason, the coal preparation plant at Cwm Colliery has been made in two separate but identical sections each having a capacity of 200 tons an hour. The two kinds of coal are conveyed from the pit at a maximum rate of 500 tons an hour and discharged into a 400-ton capacity bunker, the bunker having two compartments to receive the alternative qualities of coal. From the bunker, conveyors carry the coal to the two preparation plants. In making its announcement about the new plant at Cwm, the Board says that mechanisation of the coal-getting process has helped to send up production of deep-mined coal from 181,000,000 tons in 1946 to 210,000,000 tons in 1955, but "machines cannot discriminate between coal and dirt and, moreover, they tend to produce an increasing amount of small coal." Efficient cleaning of large coal by hand, however, is costly in manpower. The Board's method of solving these problems is by installing mechanical plants which can clean large as well as small coal, leaving only the biggest pieces to be hand-cleaned. As a result, the quantity of coal hand-treated has been reduced from 87,000,000 tons in 1946 to 47,000,000 tons in 1955, despite an increase of 16 per cent in the mined output.

Coal Statistics

THE National Coal Board has issued a statistical statement about "costs of production, proceeds and profit," for the third quarter of 1956. During that period, the amount of coal "disposable commercially" by the Board was 42,596,816 tons, and the proceeds from sales of coal totalled £179,015,975. The total costs were £177,595,886, so that the profit, before charging interest, was £1,420,089. The estimated profit on opencast working during the quarter was £2,570,000 and on ancillary undertakings, £971,000, thus giving a total profit, from the Board's activities, of £4,961,089. Provision for taxation required £437,000, and the interest payable to the Minister of Fuel and Power is given in the statement as £5,750,000. The final result for the quarter, therefore, is a deficit estimated at £1,226,411. The estimated average earnings in the coal mining industry, including the value of allowances in kind, for all adult male workers of twenty-one and over, were £13 12s. 6d. a week in the third quarter. A report by the Ministry of Fuel and Power on coal production and consumption shows that, in the week ended December 15, saleable output reached a record figure of 5,063,100 tons, of which 4,787,800 tons came from the deep mines and 275,300 tons from opencast sites. The deep-mined output was 40,000 tons higher and the opencast output 80,000 tons higher than in the comparable week of last year. Deep-mined coal production for fifty weeks of this year, ended December 15, was, however, at 203,436,300 tons, 133,000 tons below the figure for the corresponding period of 1955. An increase of 650,000 tons in opencast output brought the total production in the fifty-week period to 215,250,600 tons, against 214,733,900 tons in the comparable weeks of last year. But coal imports this year, up to December 8, totalled 5,079,800 tons, which was less than half the tonnage imported in the corresponding period of 1955.

Commonwealth Standards Conference

THE third Commonwealth Standards Conference to be held since the war will open in New Delhi on January 21. The countries which will be represented at this conference are the United Kingdom, Australia, Canada, India, New Zealand and Pakistan. The principal purpose of the conference is to secure a common approach to, and greater alignment of, industrial standards among member-countries of the Commonwealth in order to facilitate the flow of trade between these countries. There are to be technical discussions on standards for the electrical equipment of machine tools, electric cables and steel, and on the co-ordination of safety requirements for domestic electrical appliances. The conference will also consider further products for which alignment of Commonwealth standards is most urgently required. In some of the conference sessions more general matters of policy are to be reviewed. Consideration is to be given, for example, to the possibility of extending between Commonwealth countries "approval" arrangements such as that which now assists exporters of British electrical goods to Canada, and to the effects on Indian standards practice of that country's adoption of the metric system and its consequences for inter-Commonwealth trade. Among other subjects to be discussed at Delhi will be the progress made in the co-ordination of basic engineering standards between Britain, Canada and the U.S.A., and modular co-ordination, for which the delegates will have before them the first European Productivity Agency report on the subject, as well as a report on development in India. The British delegation to the conference will consist of twenty-five representatives, and in the general sessions the delegation's principal spokesman is to be Mr. H. A. R. Binney, director of the British Standards Institution.

Airways

CHANGES in the pattern of civil and military aviation since the existing air corridors were introduced in 1950 have called for a revision of the system: the Ministry of Transport and Civil Aviation is discussing with operators, pilots and other parties proposed changes. In the South East region plans have been agreed with the governments of Belgium, France and the Netherlands that will initiate during next year an airway to Belgium and the Netherlands passing over the Clacton area, a realigned airway to Belgium via Dover, and two new airways between Cap Gris Nez and this country. In 1958 a control zone for Gatwick Airport will complete the plan. New plans for Central England, to increase the capacity of the Manchester control zone, will follow. The air corridors in the Scottish Area will be reviewed to provide air space for numbers of long-range jet aircraft. Additionally, the height of the airways should be raised in 1957.

Obituary

H. J. F. GOURLEY

A very wide circle of engineers will have learned with regret of the death of Mr. H. J. F. Gourley, on December 18. Mr. Gourley was president of the Institution of Civil Engineers for the present session, and only last month he delivered his presidential address to the institution. He was a consulting engineer of considerable influence, specialising principally in water supply. The firm of which he was senior partner is noted for its works in this field, and in allied engineering design, such as irrigation and public health, many of its jobs being overseas.

Harold John Frederick Gourley was born at Liverpool in 1886 and educated at the Liverpool Institute before passing on to that city's University, where, in 1909, he graduated as B.Eng. with first-class honours. He was engaged in hydraulic research at the University for the following year, during which time he gained a Miller prize for a paper on concrete and reinforced concrete piles, presented to the North Western Local Association of the Institution of Civil Engineers at Manchester.

On completing his pupilage in 1912 with Sir Alexander Binnie, Mr. Gourley joined the staff of Sir Alexander Binnie, Son and Deacon as assistant engineer, and in 1913 was appointed a resident engineer on the Alwen Water Scheme (Birkenhead). During the first world war he served in France from 1915 to 1918, eventually commanding the 438 Field Company, Royal Engineers. Upon demobilisation he returned to Sir Alexander Binnie, Son and Deacon, and from 1920 to 1924 was chief assistant engineer. He became a partner in 1924 and, since 1949, has been senior partner in the firm, which became renamed Binnie, Deacon and Gourley.

In his professional capacity Mr. Gourley has visited Italy, Ceylon, India, Burma, Malaya, Singapore, Hong Kong, Nigeria, South Africa, the Rhodesias, and the New England States. He has been responsible for advising many authorities and has given evidence before Parliamentary Committees. He was a technical assessor at the Croydon typhoid inquiry of 1937. He was a witness for fifty-seven water undertakings (excluding the Metropolitan Water Board) at the Greater London inquiry (1947). In March, 1949, he was a member of the panel of four which inspected and reported upon the Kariba and Kafue hydro-electric projects.

Mr. Gourley's work for the Institution of Civil Engineers included membership of the Institution Floods Committee and the committee which prepared the 1938 Code of Practice for the design and construction of reinforced concrete structures for the storage of liquids. He was nominated by the Institution as a member of the Codes of Practice Committee set up by the Ministry of Works in 1942. As a student he was awarded two Miller prizes and has also been awarded two Telford premiums for papers on water supply. He was elected an associate member in 1913, and transferred to the class of Member in 1922. He was a member of the Council from 1941 to 1946, and again from 1949 until the present. He became a vice-president in 1952.

Mr. Gourley had a serious accident in 1951 when the Liverpool express was derailed at Weedon. He lost his right arm and left leg, apart from other injuries.

From a long career in which heavy responsibility has been borne in designing a great number of civil engineering projects, it is perhaps difficult to single out one or two examples to illustrate Mr. Gourley's individual contribution to the advance of his profession. However, two examples, which occupied his interests to the extent of authorship of papers at the Institution of Civil Engineers, can be cited. In 1939 he was joint author, with Mr. W. J. E. Binnie, of a paper on the Gorge dam at Hong Kong, and in 1934 he presented a paper on the water supply of Kano in Northern Nigeria.

H. J. F. Gourley

Both of these projects entailed engineering design which was unusual. For instance, at Kano alternative proposals for providing the town with an adequate water supply had to be investigated, and it was decided that a conventional impounding scheme was not the best or most economical choice. Instead, a number of intake wells were constructed in permeable subsoil in the bed of the River Challowa, and the yield from them was pumped to a service reservoir. Previous to this work the water supply of Kano had been precarious—the district has been described as one of the driest places imaginable—and water was sold in times of drought at a price of 9d. for a 4-gallon skinful. It was remarked in the discussion at the time that Mr. Gourley's work amounted, in effect, to finding an underground reservoir and an underground filter at one and the same time and making use of these two natural resources.

The Hong Kong water supply proposals included construction of a large dam, known as the Gorge dam or Shin Mung dam, with a height of 275ft. An original form of construction was chosen for this dam, largely because of the economic conditions of the area, but also because of the possibility of seismic disturbances. The dam was a rock-fill structure, but on its upstream side it consisted of a " thrust block," built of permeable concrete—a massive block form formation level up to about half the full height—with concrete buttresses resting on it, up to crest level. An impermeable diaphragm was constructed, supported on the upstream side of this concrete work, and a wedge of sand was placed between the buttresses and the rock fill, to compensate for any settlement or movement of the thrust block. Mr. Gourley's firm has also been responsible for more recent water supply works at Hong Kong, and at the present time an extensive scheme is in progress, involving a gravity dam with an ultimate height of 180ft, and subsidiary dams, tunnels, and other works.

A presidential address affords its author unique opportunity for expressing views accumulated during a lifetime's professional experience, and of describing technical innovations from first hand. Many readers of this notice will recall Mr. Gourley's address, published in abstract only last month in this journal. Suffice it to say here that Mr. Gourley dwelt on recent improvements introduced into civil engineering and used especially in water supply. But he was also concerned with the status and prestige of the civil engineering profession. He thought that the right class of experience was more important for young engineers than the size of the salary received at that stage of their careers. He also held that posts in the nationalised industries, and suchlike large organisations, tended to canalise the duties of the civil engineer, so that he was likely to be employed below his technical capacity. Leaders of the profession were not nationally-known figures as in other professions, he noted, but there was probably no cause for complaint; there was such immense satisfaction in the conception and execution of schemes that engineers became indifferent to recognition.

Mr. Gourley leaves a record of service as a consulting engineer of the highest order. In fact, the recent achievements which can be attributed to him and to his firm indicate the healthy state of the profession, at home and overseas, in the contemporary scene. At the Institution of Civil Engineers, too, his death will be sadly felt; this is, we understand, the first occasion when the Institution has suffered the loss of its president. The untimeliness of Mr. Gourley's death is doubly felt, for he made a remarkable recovery from the serious railway accident inflicted on him in 1951, in showing a courageousness which deserved, at least, a happy year in the highest post which a civil engineer can reach.

Mechanical Breathing Machines

By CAPTAIN G. T. SMITH-CLARKE

No. II—(*Concluded from page 879, December 21*)

Epidemics each summer of poliomyelitis have caused the hospitals in this country to become worried about the quality and quantity of breathing equipment available in this country. The author of this James Clayton Lecture, presented before the Institution of Mechanical Engineers on Friday, December 14, is chairman of the Coventry, Nuneaton and Rugby Group Hospital Management Committee and has been personally responsible for designing much of the apparatus, now in use, described in the lecture.

Design and Development of a New Kind of Cabinet Breathing Machine

DURING the whole of the period when the modification of the Nuffield Both breathing machines was being carried out, and particularly when " the shape of things to come " could be clearly discerned, I had many informal conferences with members of the medical and nursing professions. Inevitably there were criticism and many suggestions, practical and impractical, about what was being done,

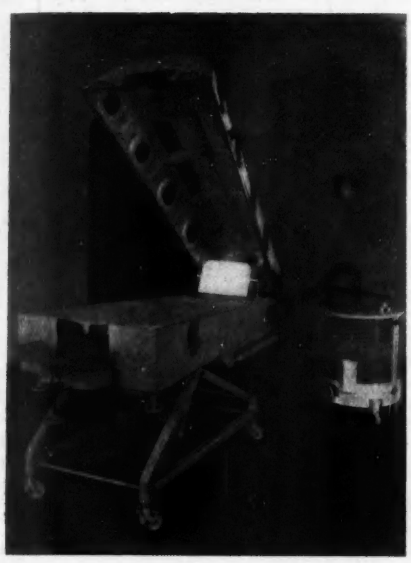


Fig. 10—First Coventry breathing machine

all of which were most carefully noted and considered. On two matters there seemed to be complete unanimity of opinion. First, that the orthodox construction—that is, the stretcher-bed sliding into a box or cylinder—had nothing to recommend it, the apparent advantage of being able to get to the patient on both sides when the bed is withdrawn is more than offset by its many real disadvantages. Secondly, that something more like a normal bed, with a cover which could be removed or opened, was the ideal to be aimed at in future design. Towards the end of August 1952, after long and careful study of the problem, I built a one-quarter scale model of an entirely new cabinet breathing machine.

The model was shown to a meeting of the Birmingham Regional Hospital Board Breathing Machine Committee, at which consulting physicians from the Region and from the Teaching Hospitals Group were present. It was later exhibited at various meetings in the Coventry, Nuneaton and Rugby Group of hospitals. The new design was hailed as a great improvement an anything known to be in use in Britain or on any other country. In Coventry the enthusiasm was so marked that various donors made entirely unsolicited contributions toward the cost of building a full-scale machine for use in the Coventry hospitals. Thus was inaugurated the " Coventry Iron Lung Fund " and about £500 was raised in a short time. Later the Coventry Coronation Carnival Committee collected some £800 which was given to the fund, and finance now being available the Coventry Hospital Management Committee placed an order with The Cape Engineering Company, Ltd., of Warwick, for a prototype machine to be produced to my instructions.

Engineers will appreciate that the model had only demonstrated the general principle of the new design, and that much remained to be done before actual production could begin. All the detail design had to be worked out so that drawings and specifications could be prepared. About this time moulded fibre glass was much in the news as an ideal material for light but very strong motor-car bodies, and after seeing samples and discussing the process I became enamoured of the idea of using this material for the lid or lifting portion of the cabinet. Proposals for manufacture were very attractive, both as to delivery time and estimated cost, but alas, promises and performance did not match up and, without going into detail, this proposal nearly wrecked the whole project. It is true that eventually a small number of machines were made with fibre glass tops but the difficulties were so great and the cost so much higher than anticipated, that the use of this material had to be abandoned. The making of this prototype proved a very tough job, but by hard work, and the whole-hearted enthusiasm of the management and staff of the Cape Engineering Company, it was eventually completed. The machine, together with a " Baby " breathing machine and a cuirasse pump, all paid for from the fund, was formally handed over to the Hospital Authorities by the Lord Mayor on behalf of the citizens of Coventry on March 23, 1954. It was called " The Coventry Mechanical Respirator," and is shown complete with the new pumping unit in Figs. 10 and 11.

It will be noticed that the head board of this machine, which carries the neck sealing

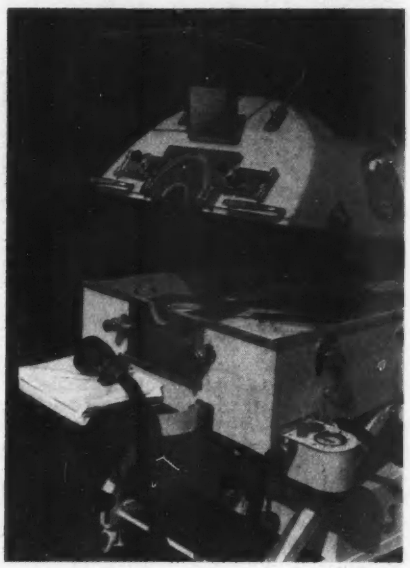


Fig. 12—Mark II cabinet breathing machine

collar, slopes backward 11 deg. above the centre-line of the neck and also slopes back 11 deg. below the centre-line of the neck. The idea behind this was that the patient could be equally comfortable lying on the back or lying face down for postural drainage. This, however, did not work well in practice and, after about eight of these machines had been made and used in various hospitals, it was decided to change the head board angles. A new series, Mark II, was brought into production and the Mark I was discontinued. The new model is of all-metal construction and is shown in Fig. 12. The auxiliary pump and control box, with

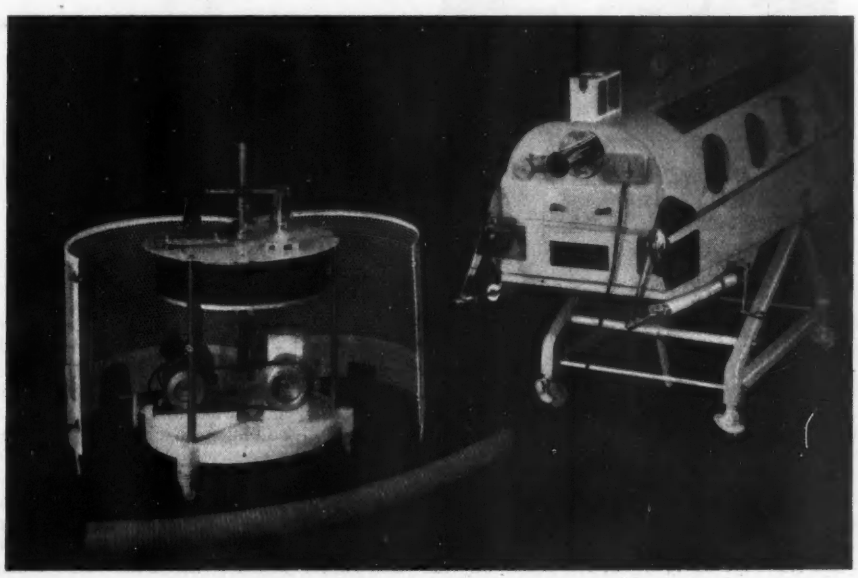


Fig. 11—First Coventry breathing machine, with pump

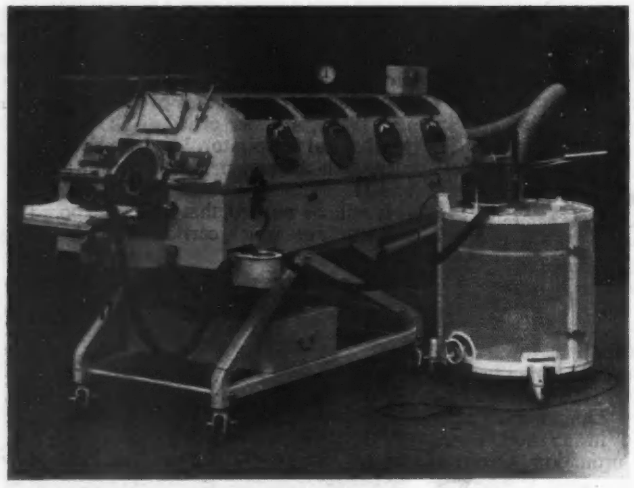


Fig. 13—Mark II cabinet breathing machine

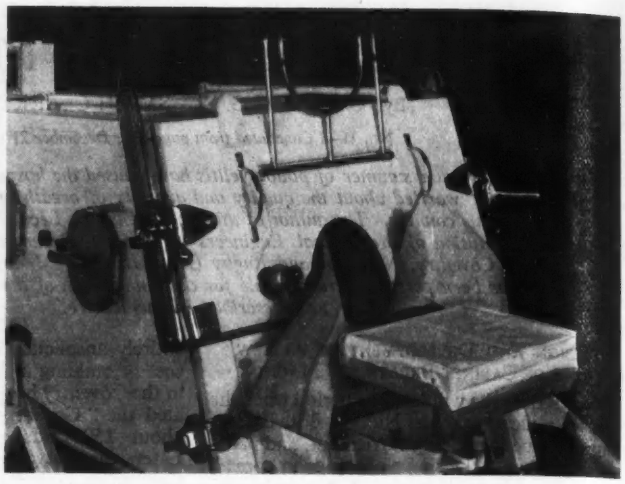


Fig. 14—Nuffield Both machine modified to take wrap-over collar

inspiratory-expiratory valve and mask, is now a standard fitting. It will be seen that the head board slopes back 30 deg. above the neck centre-line, whereas below it is vertical. Admittedly this is not perfect, but it has been found by actual experience to be the best possible compromise. It gives maximum comfort and a feeling of freedom when the patient is lying on the back, which is the position most of the time. It is only moderately comfortable for the face-down position, but for several other reasons a patient cannot be comfortable for long in that position. A new foot-board has been fitted, adjustable in all directions to ensure the means for giving maximum support to the feet, now known to be so essential.

When the machine is tilted for maximum head-down position the main pivot point has been located so that the patient's head is still not too low for easy nursing attention.

Fig. 12 shows the bed adjusting screws, controlled by handwheels below the front end of the cabinet. These are used to adjust

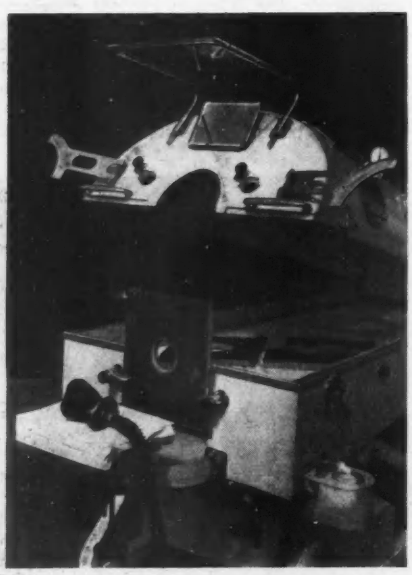


Fig. 15—Mark II cabinet breathing machine

the height of the bed to ensure that the patient's neck is comfortable in the sealing collar, and they can also be used to tilt the bed sideways up to about 3in either way to ease the patient's position as desired. The fully adjustable pillow support, the new pattern universal collar clamps, the mirror, and the reading platform can also be seen. The half collars are in position.

Fig. 15 shows the " wrap-over " collar in use. This is a very comfortable all-purpose collar and is probably the best we have at present if tracheotomy has to be carried out. It is not new, having been described in an American publication about 1948, but so far as I have been able to ascertain, it did not find much favour, probably because the collar clamps on most American breathing machines do not allow it to be used to maximum advantage.

Fig. 15 shows how one of the modified Nuffield Both machines in a Coventry

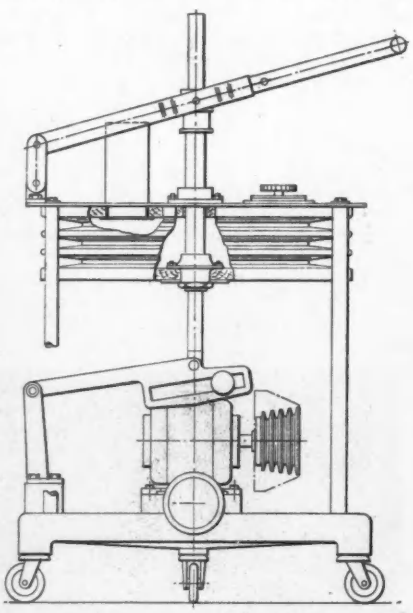


Fig. 16—Diagram of new pump

hospital has been further modified to permit the use of the " wrap-over " collar. Although the position with regard to neck sealing collars has been much improved in the last few years, the problem of dealing with a tracheotomised patient in a cabinet respirator has not been completely solved. By the time this lecture is delivered I hope that we shall have a new half-collar which will meet all requirements. I proposed such a collar when I made the first " split head " modification, but, unfortunately, to make this collar involves the use of a fairly costly moulding. The Ministry of Health cannot or will not undertake expenditure of money for anything new and unknown to them until a sample has been submitted for inspection and trial. If, however, to make the sample, costly tools will be required it probably will not be made. It is very unlikely that any commercial undertaking will risk the cost of

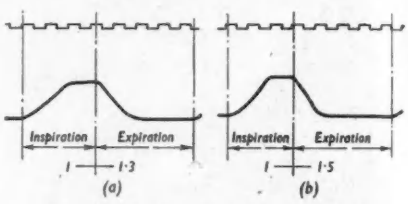


Fig. 17—Graphs of breathing patterns

tooling for an experimental article for which there can be no reasonably certain future business. To get this particular collar made I shall have to persuade someone to make a donation to cover the cost of the mould and of the trial mouldings.

The Pump Unit

The general appearance of the pump unit can be seen in Fig. 11. It is of robust construction to enable it to stand up to the hard usage it will certainly get in hospital service,

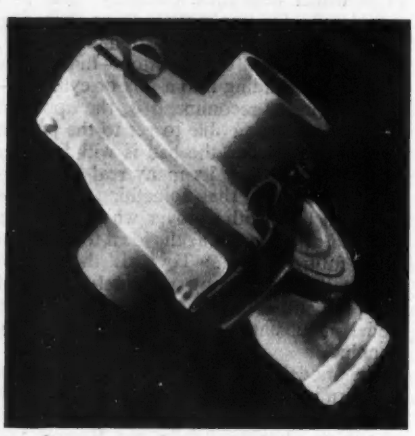


Fig. 18—Diaphragm valve for intermittent positive pressure

and is designed to be quiet in operation, simple in use and maintenance, and as reliable as it is possible to make it. Under the heading " How the Cabinet or Tank Breathing Machine Works " I mentioned that the

conventional pump unit, in which the bellows is operated by means of a crank and connecting rod, gives equal inspiration and expiration periods. Most physicians would like a breathing pattern in which the inspiration/expiration ratio is of the order of 1/1·5. Several ideas have been tried to achieve this.

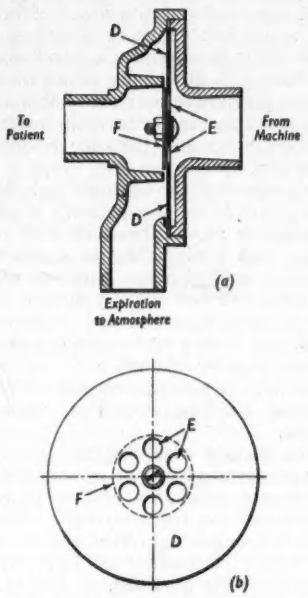


Fig. 19—Diaphragm valve diagram

In Britain eccentric gears between the final drive and the crank have been tried. In Germany, two cranks, phased to give a differential action, have been used on one machine ; and in America, it has been proposed that the crank and connecting rod should be discarded in favour of a cam-operated bellows. In my pump unit the desired result has been obtained by the use of a well-known very simple and efficient mechanism, Fig. 16. There is no connecting

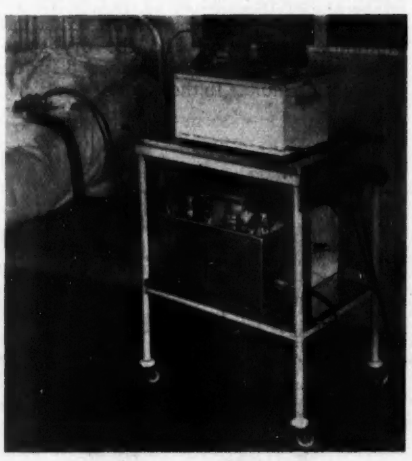


Fig. 20—Experimental intermittent positive-pressure apparatus

rod in the usual sense ; the crankpin carries a bearing block which works into a pivoted crosshead, and by suitably fixing the position of the pivot in relation to the crank centre the differential action is obtained. Fig. 17 shows breathing patterns obtained on the standard test unit (*a*) with crank and connecting rod (*b*) with pivoted crosshead.

A considerable number of the Mark II machines have been delivered to hospitals in Britain and abroad. Unfortunately,

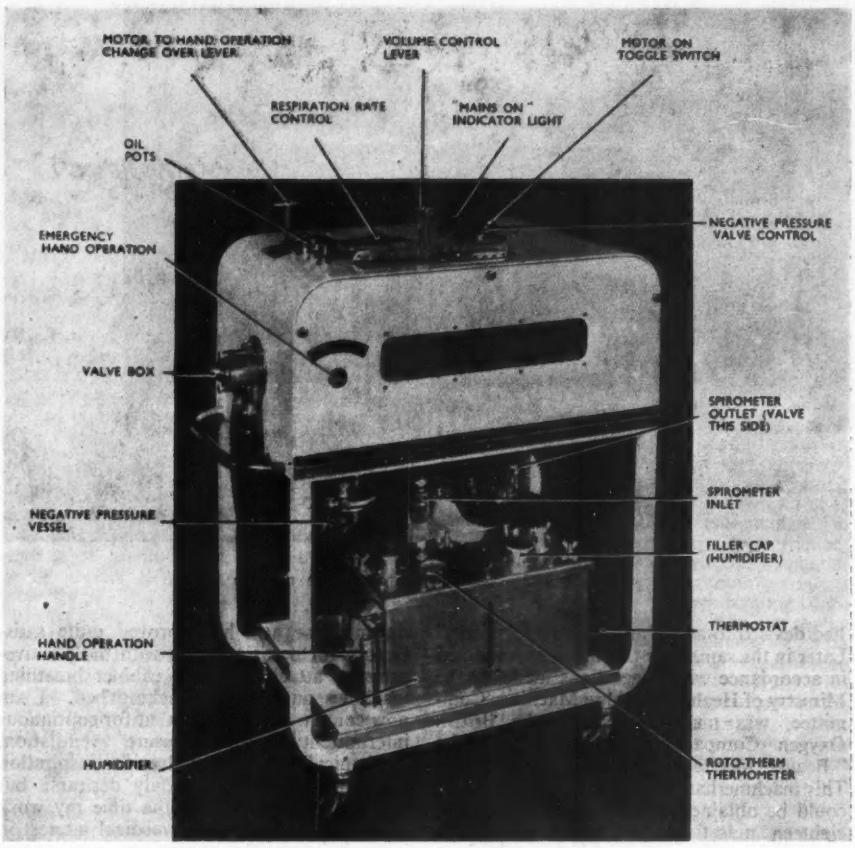


Fig. 21—Positive/negative pressure machine

many of them are already in use, but from reports received I am glad to say that the machines are giving general satisfaction.

Positive-Pressure Breathing Machines

Artificial respiration by intermittent positive pressure, or by alternating positive and negative pressure, has been known for more than a century and a half, but there is no record of it having been used to any appreciable extent until 1952. In that year there was a very severe epidemic of poliomyelitis in Denmark and, in the absence of adequate breathing machines, Professor H. C. A. Lassen and his anæsthetist colleagues devised a system of intermittent positive-pressure ventilation. Cylinders containing a 50/50 oxygen-nitrogen mixture were used with a closed circuit. Soda lime was used for carbon dioxide absorption and control was manual, carried out by relays of medical students. This system proved very costly indeed and it is not surprising that machines were soon devised to act as "artificial students." In June, 1953, the "Bang," "Aga," and "Engstrom" machines were being used in Denmark.

At a meeting held in May, 1953, at the Ministry of Health, London, Dr. R. A. Beaver demonstrated a machine which he

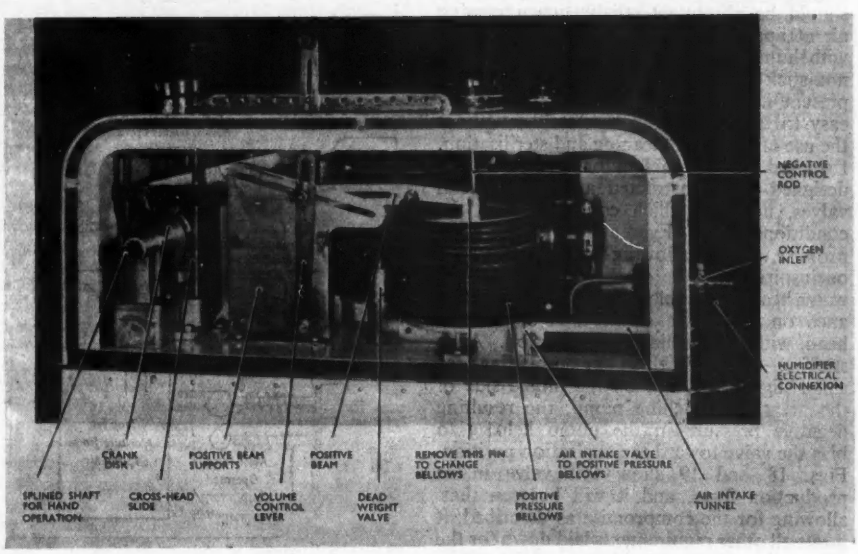


Fig. 22—Positive/negative pressure machine

Fig. 23—Positive/negative pressure machine

had devised to act as an "artificial student." Later in the same year this machine, modified in accordance with suggestions made by the Ministry of Health Breathing Machines Committee, was manufactured by the British Oxygen Company, Ltd., and called the "Beaver Mechanical Respirator, Mark I." This machine had a fixed breathing rate, but could be obtained to give either fourteen or eighteen pulsations per minute. Two of these machines were supplied to Whitley Hospital, Coventry, and they were used to ventilate patients (with face mask) whenever it was necessary to open the cabinet machine for nursing or other purposes. Being fixed-rate machines, it was not possible to synchronise them with the cabinet breathing machine and it was found that some patients objected strongly to the change in breathing rate. It was this experience which gave rise to the design of the positive-pressure attachment for cabinet breathing machines. A very difficult problem in connection with intermittent positive-pressure respiration is the design of an efficient automatic inspiratory/expiratory valve. The ideal valve should offer a very low air flow resistance on inspiration, not more than 5cm water head, and still lower air flow resistance to expiration, not more than 1cm water head. It should be absolutely reliable when passing air at approximately body temperature and with humidity at saturation point. It must not stick or fail when sticky secretions are present in the expired air, and it must be easy to take apart and reassemble, without the use of tools, for cleaning and sterilisation. I worked on this problem for a long time and designed and constructed at least a dozen valves, none of which could meet all the conditions listed. Eventually I had to compromise, and by allowing air flow resistance on inspiration to be of the order of 5-10cm water head I was able to keep air flow resistance on expiration down to 3-5cm water head, with fairly reliable valve action. Anti-sticking can be helped by providing for some slight resistance on the intake side of the breathing machine pump, the resulting negative pressure in the pump helping to bias the valve toward the expiration position. Figs. 18 and 19 show this valve in its production form, and it will be seen that, allowing for the compromise as described, it meets all other requirements laid down for the ideal valve. A large number of these valves have been manufactured and supplied for hospital use and have proved quite satisfactory for occasional use with the positive-pressure attachments for cabinet breathing machines and for the rocking bed. I am now convinced, however, that for continuous intermittent positive-pressure ventilation, mechanically operated valves for inspiration and expiration are not only desirable but absolutely essential. By the time my work on valves was completed medical interest in intermittent positive-pressure ventilation had greatly increased, and I then designed and constructed a prototype set of intermittent positive-pressure breathing equipment for use at Whitley Hospital, Coventry. This is shown in Fig. 20. The equipment was assembled on a special trolley and comprised :—

(1) The intermittent positive-pressure breathing machine.

(2) The cable-operated inspiratory/expiratory valve.

(3) The humidifier, electrically heated and thermostatically controlled, for heating and humidifying the air delivered to the patient.

The machine provided for five breathing rates, 13, 16, 19, 22, and 25 per minute, as used on the cabinet breathing machine and on the rocking bed. The inspiratory/expiratory valve was entirely mechanical, cam-operated by means of a Bowden type cable. Positive control of the volume of air delivered to the patient was obtained by varying the stroke of the pump. A dead-weight safety valve, set to lift at 25cm water head, a pressure gauge calibrated in centimetres water head, and a controllable leak valve were also fitted. By means of a two-way tap, pressure could be read at the pump outlet or at a position between the inspiratory/expiratory valve and the tube leading into the trachea.

The purpose of the controllable leak valve was to provide for the patient's comfort if the machine should be used with a face mask. This equipment was operated for some thousands of hours, partly on research work and partly on actual patients. It gave very satisfactory service, and the experience gained with it was used in the design of the completely self-contained positive/negative, or intermittent positive-pressure, mechanical breathing machine which I shall now describe.

This machine was designed to provide either positive/negative or intermittent positive-pressure ventilation and to be reliable and efficient on either system. The construction is simple and robust and any person likely to use the machine can learn, from the instruction plate provided, all that is necessary for its efficient use and maintenance. Apart from the electric motor and its indicator light and switch, the machine is entirely mechanical. There is no interference with radio or television. Fig. 21 shows the production model, and it will be seen that it is built as a unit complete in itself. It is mounted on castors and is arranged in two tiers—the upper part shown in Figs. 22 and 23 comprises the pumps, controls, driving motor, gearboxes, cam-operated mechanical valves controlling inspiration and expiration, and the mechanism for manual operation in the event of an electrical failure ; the lower tier carries the humidifier, the negative pressure vessel and expiration water trap and the dry spirometer with a parking space provided for the emergency handle. In the event of electricity,

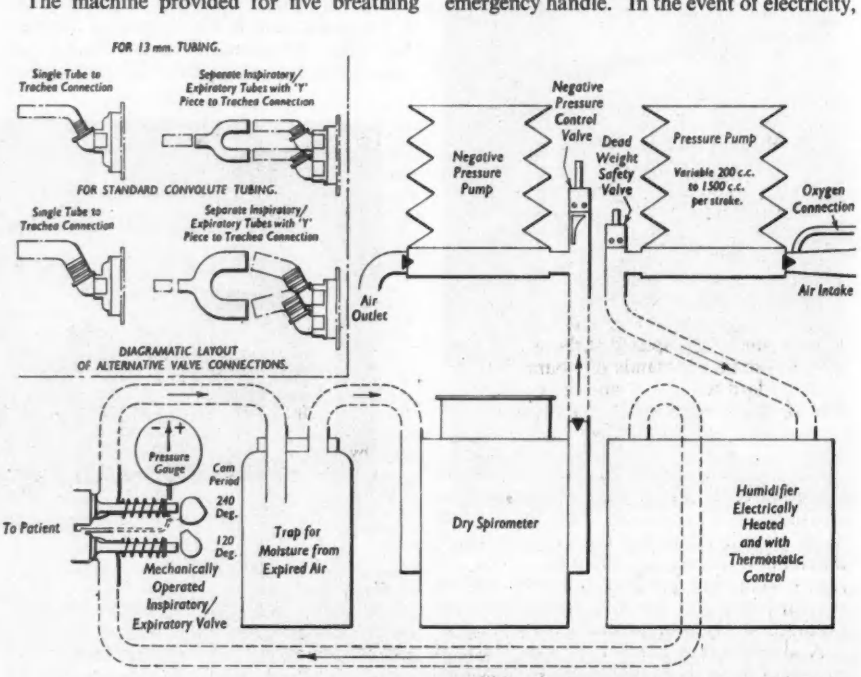

FOR 13 mm. TUBING.
Single Tube to Trachea Connection
Separate Inspiratory/Expiratory Tubes with "Y" Piece to Trachea Connection
FOR STANDARD CONVOLUTE TUBING.
Single Tube to Trachea Connection
Separate Inspiratory/Expiratory Tubes with "Y" Piece to Trachea Connection
DIAGRAMATIC LAYOUT OF ALTERNATIVE VALVE CONNECTIONS.
Negative Pressure Control Valve
Dead Weight Safety Valve
Pressure Pump
Variable 200 c.c. to 1500 c.c. per stroke.
Oxygen Connection
Negative Pressure Pump
Air Outlet
Air Intake
Pressure Gauge
Cam Period
240 Deg.
120 Deg.
To Patient
Mechanically Operated Inspiratory/Expiratory Valve
Trap for Moisture from Expired Air
Dry Spirometer
Humidifier Electrically Heated and with Thermostatic Control

Fig. 24—Positive/negative pressure machine diagram

motor or gearbox failure this handle can be fitted to the splined shaft visible in the front of the machine, and manual operation can be in action in a matter of seconds. Four controls, all clearly marked, and with simple locking arrangements, together with the compound pressure gauge, are mounted on top of the cabinet. They are (1) a lever which controls the stroke of the positive-pressure pump and so determines the volume of free air or air-oxygen mixture delivered to the valve box ; (2) a lever which operates the dog clutch to permit of motor or manual operation ; (3) a lever (on production models a wheel) which controls the variable-speed gearbox providing for breathing rates of 10-40 per minute ; this can be locked in any one of ten positions, but can also be set at any intermediate position if required ; (4) a circular knob controls the negative pressure which is provided by a separate pump. It is calibrated, " off," " minimum," " maximum." In the off position intermittent positive pressure only is supplied to the patient ; negative pressure can be adjusted for 0-15cm water head, and a dead-weight safety valve prevents any reduction of pressure beyond this range. The mechanical inspiratory/expiratory valve is built into the side of the cabinet ; there are two stainless steel poppet valves, working in a bronze

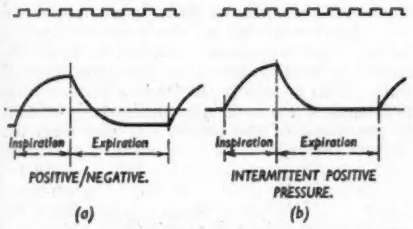


Fig. 25—Positive/negative pressure and intermittent positive-pressure breathing patterns

valve box, both inlet (inspiration) and exhaust (expiration) valves are operated by cams mounted on the pump driving shaft. The breathing pattern provided is inspiration 120 deg. and expiration 240 deg. As the period of the positive-pressure pump is 180 deg. it follows that pressure is built up in the compression space of the pump, the humidifier and the connecting pipes before the inspiratory valve opens ; this helps to overcome the inertia of the considerable volume of air in these dead spaces and ensures efficient " filling " of the lungs in the comparatively short time the inspiration valve is open. The dry spirometer can be left in circuit for continuous reading even when intermittent positive-pressure only is in use, provided always that under this condition the negative pressure control must be set to overcome the slight resistance to expiration caused by the spirometer. The prototype machine which I completed early in 1955 was tested for some thousands of hours, first on the " standard test unit " and later on actual patients. Fig. 24 shows the principle of the machine and Fig. 25 shows (1) breathing pattern, positive/negative pressure ventilation ; (2) breathing pattern, intermittent positive-pressure ventilation. At the time of writing (July, 1956) this machine is in production and seventeen have been delivered, some to the Ministry of Health and others to various hospitals in Britain and abroad.

Several of the production machines have completed upwards of 1000 hours each, working on patients under normal hospital conditions.

Tooth Gearing and Research

S. A. COULING

At a meeting of the British Gear Manufacturers Association in London on November 13, the paper, reprinted almost in full below, was presented. Amongst other matters the author suggests the setting up of a national representative body for gear research. He illustrates the need for research in design, production, metrology and lubrication.

RESEARCH may be roughly divided into two main groups, first, that which is concerned with the fundamentals of the problem, represented by pure science and, second, that which may be more properly called development, or applied research. Fundamental research must be undertaken by the scientist and this work should precede practical development. However, very often the latter by sheer necessity comes first ; the practical engineer inventing mechanism based upon the vague scientific knowledge available at the time of the invention. Tooth gearing is a typical case in point, since the laws influencing friction, one of the fundamental sciences of gearing, have not yet been completely solved. Two papers on gear failure, presented this year before the Institute of Marine Engineers, bear witness to this fact,* The primary objects of this article are to bring certain knowledge to the notice of those responsible for the gear industry, and to stimulate interest in gearing research, with a view to remedying some of the present defects in our corporate body.

History

It is not very much more than 100 years since science became part of the curriculum of the Universities and took its place with art and the classics as being worthy of study. Further, up to 1939, practically all mechanical research associated with tooth gearing of a fundamental nature was undertaken by the Universities. Since 1945 two well-known research establishments have been set up, concerned particularly with tooth gearing as applied to marine propulsion ; the Admiralty Vickers Gearing Research Association and the Parsons and Marine Engineering Turbine Research and Development Association. Neither of these two organisations is obligated to pass on to gear industry generally the results of their research. Another, more national, organisation undertaking gear research is the Mechanical Engineering Research Laboratory, but often the facilities for research and their findings are only available to our national fighting services. Fortunately for industry, certain large companies are undertaking research work in both of the above two categories, but the information in their hands may, or may not, be made immediately available to industry and, if at all, only after the passage of much time.

In addition to the above, and quite independent of them, there exists in this country a British Standards Institution responsible for issuing specifications intended to control the quality of gear production and the performance of gear units. It must be recorded that representatives from all the above organisations are members of the B.S.I. However, it is one thing to insist on working to a specification but quite another to make the knowledge available to industry as to how to meet these required standards.

A B.S.I. Committee has been considering revision of B.S.S. 436 and 721 for two or three years. The fact of the need for revision admits of advance in knowledge in the design and production of the gear covered since the original issue by the specification. The time taken to revise, which should have been a simple task, reflects the amount of time necessary to consider recent research disclosures, lack of complete knowledge and the need for still further research.

The possibility of setting up a national representative body, exclusively concerned with gear research, is offered for members' consideration. The body should consist of representatives from the existing organisations reinforced by representation from the B.G.M.A. Each representative must have full authority to present the position with regard to the research associated with the organisation he represents, and also have authority to organise further work on a systematic scale, in order to arrive at the solution of outstanding problems of gear tooth applications.

* I. Marine Engineers Vol. LXVIII No. 9.

Fundamental Research

Friction loosely defines the science concerned with the fundamental problems associated with tooth gearing. Involved and embraced by friction are several branches of science : physics, metallurgy, chemistry and mathematics, so that, to attack the problem of tooth friction, a team of scientists is necessary. One method of studying friction, as applied to tooth gearing, is through the medium of two rotating discs mounted in a special machine. The disc testing machine has been made to simulate, as far as possible, tooth gearing action. Two gear wheels in mesh, at the point of contact, roll and slide over one another simultaneously, except at the common pitch-point where rolling only occurs. It is possible to arrange discs with osculating surfaces from pure rolling engagement to combine the rolling and sliding conditions equivalent to those of teeth in operation. Much can be achieved by a systematic set of test runs, with the object of aiding the gear design engineer in the selecting of the best mating steels for both the driver and the driven gears. Further, the disc testing machine provides an excellent means of testing the values of various lubricating oils.

From very many tests results examined, it becomes at once apparent that given certain combinations of metal and of lubricants, the discs can maintain satisfactory loads, many times in excess of present gear practice. What industry must do is to discover the reason for gear failure for similarly loaded conditions to those used with successful disc tests. It is not clear why gear teeth in service are only suitable for comparatively light loads and research is needed to discover the reasons. The disc machine can also be usefully applied to the problem of gear teeth pitting and scuffing.

As an example for the need of research, in Appendix I are given simple formulæ used until recently to obtain the maximum bending and wear stress in the gear combination and in contrast, a recent formula suggested in the United States to cover the same requirements. The American suggestion is a brave attempt to consider the complete total effects influencing the performance of tooth gearing. Detail study of factor K_f discloses how much research still needs to be done before the true values can be given to these effects.

Applied Research

Associated with applied research are design, production by machine tools, metrology and, in addition, tests of gearboxes under full power loaded conditions.

Design.—It has been said, with a certain amount of truth, that the design of gear drives is simple ; the problem of successful application lies more properly in production. Apart from design, the secret of success lies in the ability to control machine tool motion in order to manufacture gear wheel teeth to very fine limits of accuracy in every detail. Attempts have often been made in design details to allow for inaccuracies both of manufacture and arising from the application, but these attempts are merely palliatives and no proper solution. Although design is simple, there are in fact quite a variety of designs of pinion and wheel details that would achieve similar power transmissions. Recently I have been able to study three different pinion and wheel arrangements as applied to cement ball

mill drives to transmit 1200 h.p. with 750/20 r.p.m. speed reduction. This point is made merely to illustrate that the designer can, and does, influence to a certain extent the final results, whereas some thirty years ago machine tool motions were sufficiently unpredictable to produce inaccurate gear wheels and to overcome the influence of gear design details.

A particular case in point and one often quoted is the application of gear drives to high-speed steam turbines for ship propulsion and turbo auxiliaries. Both Sir Charles Parsons and De Laval had to consider the machining of gear wheels before a successful drive was achieved with high-speed turbines. Sir Charles Parsons invented and developed by research his patent creep mechanism. This device aimed at scrambling indexing errors present in the gear cutting machines in such a fashion as to prevent meshing teeth, when on load, producing a musical note.

Production.—An oscillograph was produced from a set of gears under load and produced on a gear cutting machine manufactured forty to fifty years ago. It illustrated the original difficulties experienced by Sir Charles Parsons. When the gear teeth were driving under load they emitted a musical note directly related to the number of teeth in the worm wheel of the cutting machine and quite independent of the number of teeth in the pinion and wheel combination. Most English marine gear manufacturers accepted the Parsons solution to the noise problem. In the United States and on the Continent different lines of approach were made for producing high-speed gearing and without using the patented English creep mechanism.

The author arrived at a solution to this problem taking into consideration geometry and acoustics and by increasing the number of teeth in the worm wheel of the gear cutting machine, finally arriving at a number of teeth eight times that of the machine as originally purchased. All gear cutting machine tools for producing high-speed power drives are manufactured on this multi-tooth worm wheel principle and without the creep mechanism. An oscillograph from a modern gear set would illustrate the movement of noise source away from the machine tool mechanism, directly to the teeth of the gear set. The frequency of note is now dependent upon the tooth contacts per second and it is interesting to observe that the quantity of noise has been so reduced as to make a set under normal circumstances practically noiseless. Outside the United Kingdom post-cutting processes, such as grinding and shaving, have been developed with success and increasing use is now being made in this country of both these machining operations.

It would be incorrect to suggest that research on machine tool motions can cease; to the author's knowledge quite new ideas of electronic control of table rotations and movement of tool slides are being tried out. There are still a few problems facing the designers of gear cutting mechanisms, all of which can be solved by applied research.

Metrology

Someone has said "to measure is to know," and it is a fact that no worthwhile progress was made in gear production until measuring techniques of gear elements had been made available. The science of metrology has been applied to the machine tool as well as to the product, and it is hardly conceivable that the production will be better than the machine tool that would produce it.

A recently developed measuring device is that which makes use of a "master" gear and uses a "Talymin" recording set to produce a graphed chart (all in one) of pitch, form and eccentric errors. This check in a simplified form was first introduced by Parkinson and is sometimes called a composite error check. It is the author's opinion that this system of checking will be further developed and increasing use will be made of it, since it provides a ready day-to-day check of quality production. A further advantage of this kind of check is that it is automatic and it requires a minimum amount of labour to apply and interpret.

A paper entitled "Gear Measuring," by Dr. C. Timms, of the Mechanical Engineering Research Laboratory, was delivered to the B.G.M.A. in the autumn of 1954. It described the advance in measuring technique which was then available, to industry, and it is the present author's experience that the scientists' responsibility for developing measuring instruments can, and will, contribute to the gear problem as soon as our requirements are properly placed before them.

Lubrication

Another link in the successful application of gear drives is the research being carried out in the lubrication field. While the suppliers of oil have their own research establishments, they are primarily concerned with blends of oil to satisfy industry, and they are not responsible for conducting experiments with gear pinions and wheels with the idea of gear research. Gear engineers are looking for a lubricant which will accelerate the running-in of gears to remove asperities of tooling and produce a work-hardened surface in the minimum of time without changing the oil. What is wanted is a running-in medium to evaporate or disappear, so that the running-in of the gears can take place *in situ* without having to have a special running-in oil and the time to do it.

General

So far, only problems common to most kinds of gear wheels have been mentioned. It is realised that an enormous variety of gear wheels is used by industry from the smallest, used in watch manufacture to the largest, used in ocean-going vessels. Further, in the watch, it may be necessary to have a speed increase of as much as 4000 to 1 and the whole mechanism may have to be halted several times a second. These requirements constitute problems of themselves, but the experienced manufacturer of one type of gear can be useful to the manufacturer of another. Mention can be made of worms and worm wheels, bevels and hypoids. Every one of these gear representatives have research problems which are peculiar to them, as well as the problems common with all tooth transmission mechanisms

The gear engineer engaged in development research cannot dismiss from his consideration supporting shafts and their associated bearings; here, again, there are so many speeds and loads to consider, and without knowledge of the hydrodynamics of film formation, the most economical design of length/diameter ratio cannot be achieved.

With regard to efficient running of the machinery, very poor or good methods are used of introducing the oil, through the oil ways to the bearings. The problems facing the gear designer are, what kind of bearing to use in any particular case? Even in the selection of the ball and roller bearing, there are several possibilities. It is not sure, however, that these numerous possibilities help in the solution since of the variety offered one only might prove satisfactory.

It is hoped that enough has been written to illustrate that the research workers, both the scientist and the engineer, need to get together and plan systematic research to cheapen and improve quality production. Quoting, Sir Edward Appleton "believes that the partnership of science and engineering is one of the most vital associations in our economic life to-day."

The author would thank his directors for permission to present this article and would like to record his indebtedness to the A.E.I. and B.T.H. Company's research staff for their help in his gear problem and for their inspiration from which this article sprang.

APPENDIX I

Graphs of Profile Error

A co-ordinate stage stylus sensing method of measuring the tooth profile errors of large-diameter gears, in either the transverse or normal sections, has been developed, whereby any errors present can be obtained accurately to 10^{-4}in. The profile errors measured normally to the theoretical tooth flank are shown on a graph as deviations from the straight line representing the theoretical profile (Fig. 1). This method of measurement was first used to find the profile error of a 54½in P.C.D., 4 D.P., spur gear ring, which had been hobbed by a large lead angle hob of involute helicoid form, and nominally to B.S.S. 436 with the tip relief. The resulting flank profiles are shown (Fig. 1), and it is evident that a rather excessive tip relief commences below the pitch line. In view of these results it was thought that the hob did not conform to its (hob) specifications, and was therefore considered unsuitable. A new special hob was ordered, incorporating no relief other than a small tip and root radius, our own standard practice. Two blanks were then cut to the same particulars as the original gear ring, using the new hob. In one case, the hob mounting errors were $3\text{in}\times10^{-4}$in and $5\text{in}\times10^{-4}$in, 180 deg. out of phase, and in the other the errors were $1\text{in}\times10^{-4}$in at either end of the arbor, and in phase. Both sets of flanks were measured (Fig. 2). In the former (Fig. 2) the maximum profile error was $4\text{in}\times10^{-4}$in, discounting the tip deviation, and in the latter (Fig. 3) it was $2{\cdot}5\text{in}\times10^{-4}$in. It is therefore evident that the maximum profile errors differ by approximately half, due presumably to the difference in hob setting. It will be also noticed that the profile errors in both cases follow the same general form. This is seen in the leading flanks of the two cases where a definite similarity is evident in the shape of the graphs. It illustrates the importance of extremely accurate hob settings necessary to obtain accurate gear profiles.

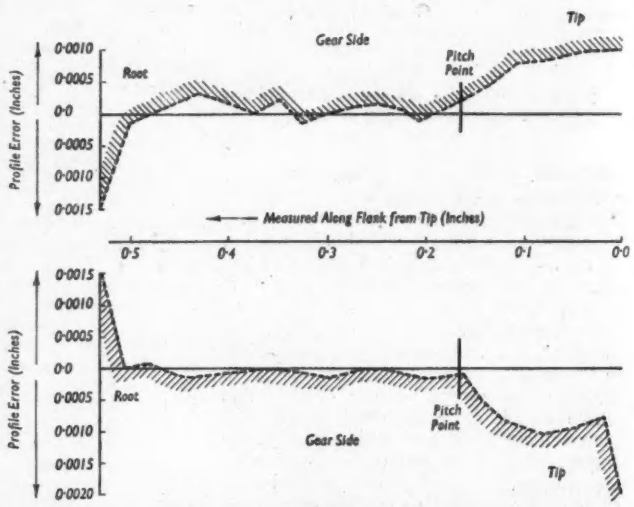


Fig. 1—Transverse profile errors on a 4 D.P., 52·5 P.C.D. spur gear ring hob, B.S. Grade A, tip relief No. 436 B.S.S.

The Effects of Hob Form on Gear Tooth Profiles

A method of analysis has been developed whereby, knowing the form of hob to be used, the resultant gear tooth profile co-ordinates can be calculated. The final equations of the analysis are given in Appendix II, but are too complex to be discussed here, but some examples of the profile errors produced by various hobs are shown (Fig. 4). It has been proved that the involute helicoid hob is the only hob which is theoretically capable of producing a perfect involute helicoid gear. Hobs ground straight-sided in the normal and axial sections produce a transverse tooth form which is convex with respect to the theoretical involute. The theoretical profile errors of a 48in P.C.D., 4 D.P.,

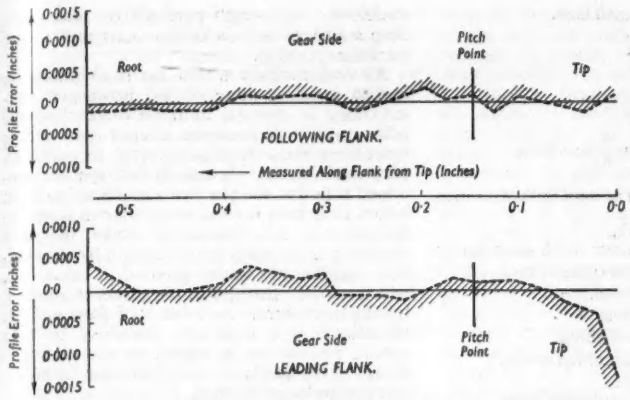


Fig. 2—Traverse profile errors of a 4 D.P., 52·5 P.C.D. spur gear ring. Hob eccentricity 0·0003in and 0·0005in, out of phase

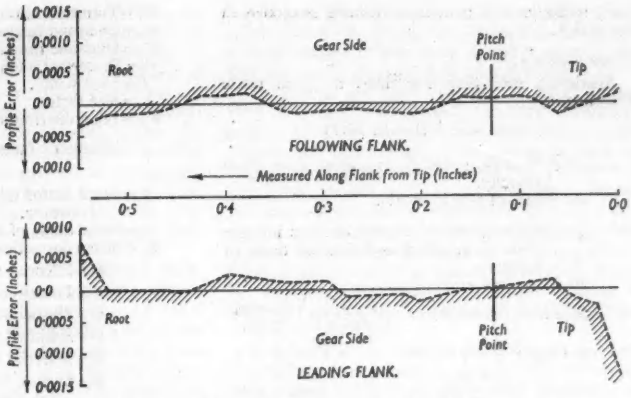


Fig. 3—Traverse profile errors of a 4 D.P., 52·5 P.C.D. spur gear ring. Hob eccentricity 0·0001in

30 deg. helix gear wheel are given (Fig. 4) when generated by a 1½ deg. lead angle hob, first, with an axially straight hob and, secondly, with a normally straight hob. The profile error is plotted against the gear tooth polar radius. The theoretical profile errors produced by a hob ground straight-sided in the axial section, the profile errors produced by a B.S.S. relieved hob and the profile errors produced by a normally straight 1½ deg. lead hob are given (Fig. 4). The axially straight hob has a theoretical tip and root relief of 2in and $2\cdot5\text{in}\times10^{-6}$in measured normally to the theoretical involute, whereas those of the normally straight hob are 2in and $3\text{in}\times10^{-6}$in. The profile errors of the same gear hobbed by a 2 deg. lead hob are also given (Fig. 5). In the axially straight hob the tip and root reliefs are 4in and $5\cdot5\text{in}\times10^{-6}$in, those of the normally straight hobbed gear are $5\cdot5$in and $6\cdot5\text{in}\times10^{-6}$in. It is evident that a small increase in hob lead angle can in the case of axially and normally straight-sided hobs produce a relatively large increase in tip and root relief. It is thought that, in practically all cases of helical gear teeth, a normally or axially straight hob should be used, in order to generate a purely geometric form of tip and root relief of the order of tenths of a thousandth of an inch.

The arguments for the introduction of the type of geometric relief are :

(1) Helical gears require an extremely small amount of tip relief.

(2) It is very difficult to introduce such a small relief smoothly into an involute helicoid hob, by virtue of having to depart from the straight generator in the hob dedendum.

(3) This relief can be introduced simply, accurately and smoothly by specifying a normally or axially straight hob with a fillet root profile to cut a tip chamfer only.

APPENDIX II

Formulae Governing Relationship Between Hob Form and the Transverse Profile Errors of the Gear Hobbed

The gear tooth profile error ε occurs at a gear tooth polar radius P, such that

$$\varepsilon=-\frac{\sec\psi_H\sin l}{\sec\psi\cos\sigma}[(x_T^2+y_T^2-R_0^2\cos^2\psi_N)^{\frac{1}{2}} - R_0\cos\psi_N(\tan\psi_H+\theta_H)] \quad . \quad (1)$$

and

$$P=R[1+(\tan\psi+\theta)^2]^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The values ψ_H, R_0, l, x_T, y_T, θ_H and θ being obtained from the following equations.

$$\psi_H=\cot^{-1}\left(\frac{\cot\psi\sin l}{\cos\sigma}\right) \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$R_0=\frac{S\cos\sigma}{2D\sin l} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$x_T=R_0[\sin\omega(1+\omega\cot\psi_H) - \tan\chi\{\omega\sin\omega\tan l(\cot\omega+\cot\psi_H)\}] \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$y_T=R_0[\cos\omega(1+\omega\cot\psi_H) + \tan\chi\{\omega\cos\omega\tan l(\tan\omega-\cot\psi_H)\}] \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$\theta_H=\tan^{-1}\frac{x_T}{y_T}+\tan^{-1}\frac{(x_T^2+y_T^2-R_0^2\cos^2\psi_H)^{\frac{1}{2}}}{R_0\cos\psi_H}-\psi_H \quad . \quad . \quad . \quad . \quad (7)$$

$$\theta=-\frac{R_0\theta_H\sin\psi_H\cos\psi_H}{R_P\sin\psi\cos\psi} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

R_P=Pitch circle radius of gear produced.
R=Base circle radius of gear produced.
ψ=Transverse pressure angle of the gear (circular plane).
σ=Pitch helix angle of gear.
D=Diametrical pitch.
R_0=Hob pitch circle radius.
l=Hob pitch lead angle.
S=No. of hob starts.
ψ_H=Hob transverse pressure angle (circular plane).
χ=Angle specifying hob grinding section. For an axially straight hob $\chi=0$. For a normally straight hob $\chi=-l$ (this is only true in the case of normally straight hobs where both flanks of the hob tooth are generated independently).

The method of using these formulæ to produce a graph of theoretical transverse profile error against tooth polar radius is given below.

(1) Suitable values for R_0 and l are calculated from equation (4), and ψ_H is calculated from equation (3).

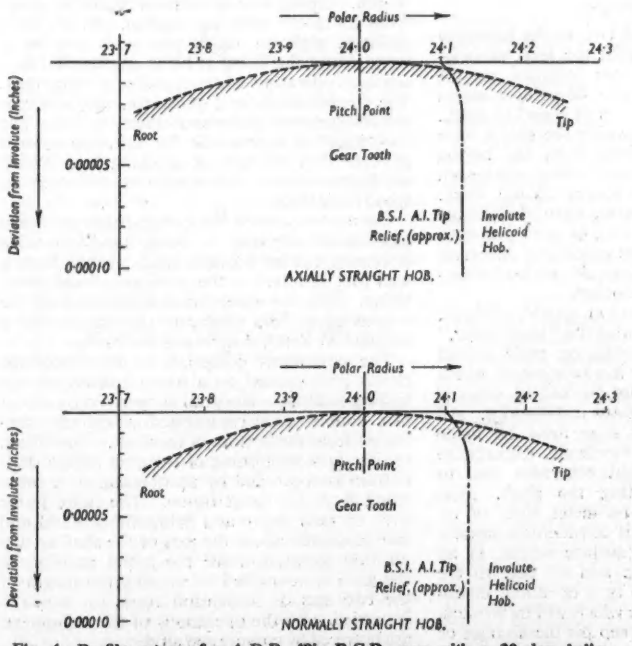
(2) Various values for ω are substituted into equations (5) and (6), giving pairs of values of x_T and y_T, which, in turn, give corresponding values of θ_H from equation (7). From equation (8) and the values of θ_H the values of θ are then calculated.

(3) These figures are then substituted into equations (1) and (2) to give several values of ε and P, which can then be graphed.

APPENDIX III

Gear Loading Formulae

Below are compared simple formulas much used



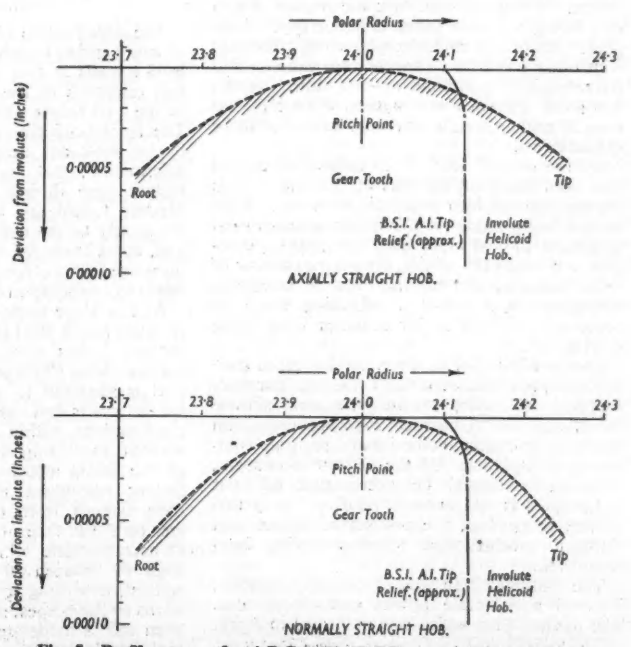


Fig. 4—Profile errors of a 4 D.P. 48in P.C.D. gear with a 30 deg. helix, when generated by a hob of 1½ deg. pitch lead angle

Fig. 5—Profile errors of a 4 D.P., 48in P.C.D. gear with a 30 deg. helix when generated by a hob of 2 deg. pitch lead angle

until recently, with a modern formula suggested in the U.S.A.

Older Formula :

Maximum safe tangential load at pitch circle (bending) is :

$$W = \frac{SAY}{P} \text{ (Lewis, 1893)}$$

S = Allowable stress for material at a given velocity.
A = Width of face in inches.
Y = Outline function (depending upon number of teeth in wheel and pressure angle of teeth).
P = Diametral pitch of gear.

Safe load (wear) $W_c = CSA\left(\frac{600}{600+V}\right)$ (Logue, 1910).

C = Hertz $\frac{1}{\frac{1}{R_1}+\frac{1}{R_2}}$

S = Safe crushing load.
A = Face width in inches.
V = Pitch line speed in feet per minute.
R_1 = Pinion radius, R_2 = Wheel radius } Involute at P.C.

Modern Suggestion :

Maximum bending stress

$$S_t = \frac{W_t k_o}{K_v} \cdot \frac{P_d}{F} \cdot \frac{K_s K_m \dagger}{J}$$

W_t = Transmitted tangential load.
K_o = Overload function.
K_v = Dynamic function.
P_d = Diametral pitch.
F = Face width.
K_s = Size factor.
K_m = Load distribution.

J = Geometric factors $= \frac{Y}{K_f} m_N \cos \psi$

Y = Form factor taken at most critical position of loading.
ψ = Helix angle of teeth.
K_f = Stress correction factor which depends on :
(1) Effective stress concentration.
(2) Location of load.
(3) Plasticity effects.
(4) Residual stress effects.
(5) Material composition effects.
(6) Surface finish.
(*a*) Gear production finish.
(*b*) Resulting from service.
(7) Hertz stress effects.
(8) Size effect.
(9) End of tooth effects.

m_N = Load sharing factor, composed of :
(1) Profile contact ratio.
(2) Face contact ratio.
(3) Crowning effect.
(4) Strengthening effect of unloaded ends.

† A.G.M.A. publication 229.03 (1956)

Post-War Development in the Coal-Mining Industry

By A. YOUNG, H. A. LONGDEN AND B. L. METCALF*

Here we abstract from a paper presented at the Institution of Civil Engineers on December 18. In the full paper, the main technical developments which have taken place in the constructional sphere in British coal mining since 1945 are described, and the history of the preceding years, as it bears on the post-war situation, is explained. The following abstract is limited to a brief statement on the "National Plan for Coal," and an account of trends in underground development works.

THE "National Plan for Coal" was published in 1950. Briefly, it envisaged the investment of £635 million between 1950 and 1965 and was related to an estimated demand for 240 million tons of coal in the years 1961/65. It proposed the construction of twenty-two new collieries and fifty-three surface mines, together with the major reconstruction of sixty-seven existing collieries and the minor reconstruction of 192 others. It will be seen that the reconstruction of existing collieries forms a major part of the plan. About 100 collieries were to be combined with other collieries to concentrate winding and coal-cleaning operations as one unit. About 300 small collieries with a total output of less than 50 million tons a year were scheduled to be closed down.

By the end of 1955, £323 million of capital had been spent on schemes at collieries. This expenditure fell into two main sections : £128 million being spent on 179 major schemes each scheduled to cost more than £250,000 on completion ; and £195 million on a large number of minor schemes and routine plant replacements throughout the industry, including those at collieries at which major schemes were being carried out.

Of the 179 major schemes costing more than £250,000, fourteen were new collieries, four were reopened collieries, twelve were new surface mines and the remainder were reconstruction schemes for existing collieries and separate coal-preparation plants. Of the £128 million spent, however, it should be noted that all but £11,500,000 is still in the "pipeline," only two colliery reopenings, five new surface mines, and thirteen reconstruction schemes having been completed.

The National Plan was of necessity flexible ; in 1955 a full-scale review was carried out. The Revised Plan which was published in April, 1956, envisaged the further expenditure of about £800 million in the period 1955/65 on collieries and associated activities, of which about two-thirds would be absorbed by major schemes each costing more than £250,000. It provided for an estimated output of 228 million tons a year by 1960, and 240 million tons a year by 1965.

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Shaft Sinking

The construction of the two shafts necessary at every mine, together with the level or near-level tunnels at two or more horizons, are the first essentials in the process of gaining access to the coal seams which it is intended to work. The formations through which the shafts have to be sunk are ascertained from the boring information, but inevitably some unforeseen factors arise during the course of the work. Modern techniques, however, have contributed immensely to the overcoming of such problems and, apart from the delays necessarily incurred, there are few problems which do not lend themselves to one solution or another.

At this stage some mention should, perhaps, be made about what is termed the "shaft pillar," because it has some bearing on underground constructions. This pillar is a zone within which coal is sterilised to ensure permanent support for the shafts and the pithead installations. All constructions within the zone must be made without permitting any significant disturbance of the strata which might otherwise lead to further movement affecting the shaft. The zone extends from the perimeter line, of an area on the surface which is considered necessary to accommodate all the surface works, at an angle of between 30 deg. and 45 deg. to the vertical, according to the type of strata, downwards to the deepest seam which will be worked. Even with a moderately deep pit the amount of coal sterilised within the pillar can amount to 5,000,000 tons in the several seams and it is, therefore, important, particularly with very deep seams, to reduce the perimeter area to the minimum possible.

All constructions within the shaft pillar are looked upon as more or less permanent constructions in contrast to those external to the pillar where movements caused by mining operations make it impracticable to construct permanent works. It should perhaps be mentioned here that the practice with regard to shaft pillars in Britain is somewhat different from the practice on the Continent, where the coal measures are in many cases overlain by considerable depths of waterlogged drift materials, which are very sensitive to the effects of adjacent mining operations. As a result of these difficult conditions it is invariably necessary to take special precautions in regard to the structural design of the shafts to resist distortion by movement of the loose material.

The trends in shaft construction to-day are :

(*a*) The adoption of mechanical mucking in the shaft.

(*b*) The increased use of the freezing process for sinking through heavily watered strata.

(*c*) The normal use of concrete in place of brick and cast iron for lining.

The normal procedure of sinking a shaft is to excavate and subsequently line with concrete in heights of between 50ft and 100ft, the lining being secured to the side by an undercut at the bottom of each stage. The practice in Britain so far has been to sink and then line in consecutive operations, although these operations have been successfully carried out simultaneously elsewhere. In contrast to many deep excavations employed on civil engineering constructions, the whole of the shaft area is kept clear of any struts, which would otherwise interfere with the sinking scaffold suspended from winches at the surface. Sinking operations are necessarily a slow process, owing to the restricted area of working, and are obviously a bottleneck in the development of a new mine. Because of this, consideration is continually being given to the adoption of any methods which would speed up the rate of sinking. Double-drum winders or two separate winders are now being used at many sinkings to accelerate the winding of dirt which is particularly important at the greater depths, and mechanical mucking is being adopted in the shaft bottom.

Twenty-nine sinkings are in progress at present ; in most of them the shafts will be 24ft diameter. Single-drum winding is being employed on twenty and double-drum on nine, whilst hand mucking is in use at eighteen and mechanical mucking at eleven of these sinkings. The average highest rate of sinking (including lining) taken over the whole country has been 32 yards per month. Individual highest rates of sinking range from 23 to 80 yards per month. In all these sinkings, eighteen shifts per week are being worked and the lining is being constructed as a separate operation while mucking is suspended. The circumstances are, of course, very different as between some shafts and others, but after due allowance has been made for this, the records indicate that mechanical mucking and double winding make a substantial contribution to speed of sinking.

On all but one of the eleven shafts in which mechanical mucking is being used, mucking is carried out by a cactus grab worked from a wall unit attached to the previously constructed lining. The one exception is operated from the suspended scaffold similar to the practice being adopted in South Africa and Germany.

The equipment comprises a power-operated cactus grab carried on a frame attached to the sinking scaffold. The grab is operated by means of a double-acting compressed air cylinder controlled from the bottom of the shaft. The lifting, raising, and positioning of the grab on the shaft bottom is controlled by an operator in a cabin slung from the hoist frame. The hoist frame runs on rails above and below the scaffold and can be rotated about the axis of the shaft to any position required, while the radial position of the grab is controlled by varying the length of the two sets of suspension ropes on which it is carried. All the operations of this equipment are powered by compressed air.†

† See THE ENGINEER, November 18, 1955, page 726.

During sinking operations the scaffold to which the grab is attached is secured on retractable joists wedged into the pockets which are constructed in the lining to receive the ends of the buntons (i.e. the cross members) used to support the shaft guides.

The scaffold is carried on four ropes from winches on the surface, the two outer of which are attached by bull chains to the scaffold, while the two inner are attached by a hydraulic device which ensures that the known minimum load is taken by these inner ropes. A satisfactory tension of all the scaffold ropes is essential, for they serve as guides for raising and lowering the hoppits. During firing operations the scaffold and grab equipment is wound up the shaft to a convenient height by means of the surface winches in the normal way.

This equipment appears to have the advantage of greater mobility over the wall unit and although experience with it is only in the initial stages, it holds out promise of speedier mucking operations.

Further increase in the speed of shaft sinking may be looked for in two directions. Under the present practice of sinking and lining in consecutive operations it will be necessary to speed up each of these operations by even more efficient mucking, by correspondingly greater winding capacity, and by speeding up the lining operation. Having done so, the unproductive period of the change-over from sinking to lining still remains. To overcome this discontinuity of working it may be necessary to reconsider the practicability of carrying out mucking and lining operations simultaneously, having due regard to statutory regulations and considerations of safety.

Construction in and through water-bearing strata is one of the mining engineer's major problems in the matter of shaft sinking. Whilst this problem gives rise to many and varied difficulties in different types of strata, it is possible to deal with these difficulties by means of one or other of the accepted techniques, although sometimes at considerable cost and expenditure of time. It still remains to decide initially which method will be the most suitable and economical for the anticipated conditions.

The cementation process, which is well known to civil engineers, is used extensively in shaft sinking for dealing with water where the strata conditions are suitable. The process is necessarily slow, but it is particularly applicable for dealing with water-bearing strata as and when they are encountered during the course of sinking. Instances have been known, however, where it was found necessary to drain off the water trapped in a particular stratum before an effective seal could be made. An advantage of the cementation process is that the effective sealing of the fissures in the strata around the shaft ensures that the "make" of water will not be excessive if the shaft lining should subsequently be damaged by movement.

The freezing process is now extensively used for sinking shafts in locations where there is a thick overlay of waterlogged drift material or in certain heavily watered sandstones, where the cementation process is not readily applicable. The process is not new, having been used on the Continent as early as 1885 to complete the sinking of a shaft in Belgium, but it was not until the present century that the process became more widely used.

The principle in the process is to form a pillar of frozen strata penetrating sufficiently far into a dry underlying strata to allow a shaft to be sunk within it and be sealed off effectively within the dry strata.‡

A circle of boreholes is put down with linings around the shaft. Brine is cooled to a temperature of about 4 deg. Fah. by ammonia refrigerating plant; it is then circulated in the boreholes through a pipe extending the full depth within the borehole and returned to the heat exchanger via the borehole itself on a closed circuit. The ice wall is gradually built up outwards from the boreholes, joins up between boreholes, and extends outwards and inwards to the centre of the shaft. It is usual to sink a bore in the centre of the shaft with a perforated lining which will allow the excess water arising from expansion from freezing to escape to the surface; the same means serves to indicate when the ice wall has reached the centre. The process of freezing is accompanied by a certain amount of heave at the surface requiring special precautions in the erection of the headgear and adjacent buildings. After the shaft has been sunk within the frozen area and lined, the surrounding ground is unfrozen by the reverse process of circulating tepid water instead of brine before further sinking proceeds. In this way the construction is confirmed before further operations are embarked upon.

The heave referred to in the preceding paragraph affects any surface structures founded in the vicinity of the shaft and it is therefore usual to defer the erection of the foundations of the permanent works until unfreezing has been completed and the ground has settled again. Where, however, it is expedient to construct such foundations in advance of, or during freezing, allowance must be made for such subsequent adjustment of the finished levels as may be judged necessary.

Where pile foundations are necessary on a site where the freezing process is being used, a further problem arises, namely, the effect of piling operations during the time the ice wall has to be maintained. If the piling has to be carried out during the freezing period within a certain distance of the shaft the type of piling adopted must be such as will not disturb the ground to an extent that will damage the freezing tubes or break the ice wall. The same considerations, of course, apply to piling operations in the immediate vicinity of a completed shaft with a view to avoiding any damage to the actual shaft lining. In both cases the choice of piling lies between one or other of the several types of bored pile.

At Lea Hall Colliery in Staffordshire, now under construction, the freezing was carried out to a depth of about 700ft on both shafts. The time required for freezing was about four months, whilst the unfreezing took slightly less.

Up to the present time the freezing process has been carried out between the surface and some predetermined underground level. There are proposals, however, to use it locally at a certain depth in a shaft now being sunk in Durham, to cope with a bed of running sand which is known to exist. In this case, the shaft will be belled out immediately above the depth in question to provide space in which the boreholes can be sunk, but the refrigerating equipment will be at the surface and the brine will be circulated to the boreholes by pipes within the completed part of the shaft.

An important point which must not be overlooked with the freezing process wherever it is employed, is the necessity for plugging the freezing holes effectively after they have served their purpose. Cases have been known where this operation has not been effectively carried out and where the consequences have been extremely serious. These freezing holes must penetrate into the impervious strata underlying the heavily watered deposits so that an effectively sealed ice wall can be formed for excavation purposes in the first instance, and an equally effective permanent watertight seal can be made between the shaft lining and the impervious mass. The shaft lining is, of course, designed to withstand the prevailing water pressure within the depth of the water-bearing strata, after which it may only continue deeper as a comparatively thin wall incapable of taking any significant water pressure. Any build-up of water pressure against this further lining must therefore be avoided at all costs. The sealing of the freezing holes is a major factor in this issue because of the ever-present possibility of disturbance and fissuring of the otherwise impervious strata.

Shaft Lining

Concrete is now normally used for lining shafts instead of brickwork or cast iron segments. It is considered to be more economical than brickwork, it involves less excavation, it is quicker to construct, it avoids the introduction of specialist labour in the sinking team, and it will require less maintenance.

Where structural considerations apply, as in the case of water pressure, the thickness of concrete is determined from the Lamé formula; otherwise it is based on empirical practices. Reinforcement is used only where movements in the strata are considered to be a possibility.

To reduce the time used in lining, sufficient steel formwork is employed to shutter a complete section of walling so that the concreting and the subsequent dismantling of the shuttering can be carried out continuously with a progressive movement of the scaffold in each case. Where the freezing process is employed, or where any seepage exists, the protective sheeting used during the sinking operations is left in position behind the concrete to allow percolating water to run free. The space behind this sheeting is later grouted through pipes built into the lining as it is constructed.

The methods of transporting the concrete from the mixing plant at the surface to the formwork vary considerably from project to project. In some cases it is delivered by special hoppits to containers on the scaffold, from which it is delivered through flexible tubes to any part of the lining. In other cases it has been dropped in pipes to containers on the scaffold, in which it is remixed before being delivered to the lining. Tests have shown that there is no significant loss of strength with the latter method—contrary to what one would have expected. Pumping has been used but is not favoured on account of the danger of blockages and the subsequent loss of time on concreting schedules.

The advantages to be obtained from the lining of shafts by concrete are so great that an investigation has been made into the possibility of using this method even where the freezing process in sinking was necessary. From this it was established that the concrete placed against frozen ground would have three days to harden before its temperature fell below 36 deg. Fah. and that a strength of 3000 lb per square inch at three days would be sufficient to inhibit any frost action which subsequently penetrated the concrete as the chemical action of hardening slowed down and eventually ceased. A ½in thick layer of concrete on the interface would have its nature destroyed, but the material could still be considered as a fully compacted sandy gravel. As a result of these tests a 5 : 1 concrete with a water/cement ratio of 0·44 was recommended for the lining of frozen shafts.

Some temperature recordings were made at three points in a section of lining at Beavercoates new sinking. The temperature of the concrete remained above 43 deg. Fah. for nine days in this case and did not approach freezing point until the nineteenth day. In the interval two grout injections were made on this section of lining, each being followed by a slight temperature rise. The concreting of the next section down in the shaft was also followed by a similar rise in temperature, particularly at the lowest recording point in the section in question. These recordings fully support the predictions made as a result of the preliminary investigations, which have been further confirmed by similar experiences in Holland and elsewhere.

The principal requirement with concrete lining is that it should be reasonably watertight, especially in heavily watered strata. This requirement, however, is not easily achieved with water pressures of the order of 260 lb per square inch and the conditions under which the concrete is placed in a frozen shaft. The temperature changes to which it is subjected in such shafts make the problem even more difficult.

The thawing out of the ground immediately adjacent to the concrete lining is generally accompanied by some seepage through hair cracks in the newly set concrete, which is arrested by grouting behind the wall, but this process has to be repeated many times and at considerable expense subsequent to unfreezing before a satisfactory degree of watertightness is achieved. Immediately thawing starts the temperature of the concrete begins to rise. This gives rise to two kinds of movement which appear to act in opposition. First, the concrete expands as the temperature rises; secondly, resumption of the curing of the concrete is accompanied by shrinkage. The fact that successive grout injections have to be made seems to indicate that the amount of shrinkage is always greater

‡ See The Engineer, September 23, 1949, page 355.

than the amount of expansion, which is further confirmed by the necessity to continue grouting operations for a considerable time, presumably until the concrete has reached a static stage in its chemical process.

It will be appreciated that it is a serious and costly matter to make concrete shaft linings adequately watertight where the head may be 700ft to 800ft of water, or even more in exceptional cases. Grouting is the current solution in Britain, and thus far the method has been considered satisfactory. On the Continent, however, a number of shafts have been waterproofed with bitumen linings sandwiched between an outer brick lining and an inner structural concrete lining, but in these instances the circumstances were rather different from those normally obtaining in Britain. In some parts of the Continent the shafts pass through a much greater depth of cohesionless waterlogged material above rockhead, which material is liable to move as a result of mining operations in the vicinity and produce flexure in the shafts. In one instance, for example, 3in thick bitumen lining has been provided between the outer brickwork and the structural concrete for the twofold purpose of protecting to some degree the shaft against flexure, and waterproofing the shaft lining should the flexure be sufficient to produce cracks.

The shrinkage which takes place in concrete as it hardens is the chief impediment to watertightness in concrete construction. Despite whatever care may be taken in the choice of materials, in the reduction of the water content of the mix, in the placing and compaction of the concrete, and in the curing, some shrinkage and cracking invariably take place. The amount of seepage, which results from this cracking in water-containing or water-excluding structures, such as shafts, then depends on the active pressure of the water.

The increasing use of prestressing or post-stressing of concrete in water-containing structures above ground prompts the question as to whether somewhat similar treatment could be applied in the case of shaft linings. Since the major shrinkage effect is in the vertical or lengthwise direction it might be possible to use flat jacks between successive heights of lining to produce a stress in the lining which would offset the shrinkage effect. Another answer might be the use of a special cement, which would produce an expanding rather than a shrinking concrete, always providing that the amount of expansion could be satisfactorily controlled. Whatever expedients might be possible, the question remains as to whether any of them would give a more effective result at less cost than the successive application of grout.

Tunnelling

Broadly speaking, tunnelling or roadway drivage as it is known in the mining industry, falls into two categories, i.e. roadways driven in and following the coal seam or roadways driven as a cross measure designed to intersect and provide access to two or more seams.

On the Continent, where it is common not only to have highly inclined seams but to have a much greater density of seams in a relatively thin section of strata than is the case in Britain, it has for many years been the practice to drive level roads designed to intersect a series of seams. This is the method known as horizon mining. It will be appreciated that to drive roadways in the solid involves a considerable capital outlay before the seams can be developed productively and that the return on capital outlay in an horizon roadway is determined to a large extent by the number of seams intersected, which in turn depends on the gradients of the seams and their density.

Generally speaking, however, the coal seams in Britain are fairly level, with the exception of the Lancashire, North Staffordshire and Scottish coalfields, where it is not uncommon to work in gradients as steeply inclined as 1 in 3. In South Wales also, where there is severe local folding of the coal measures, working can and does take place at almost any gradient. In the normal way, however, working in seam gradients, which for the most part are level to 1 in 15, it has been the practice to drive haulage roadways in and following the coal seam. Indeed, this system has been the one normally adopted in seams with a gradient as high as 1 in 3. This practice was adopted as being much more economical to meet our conditions and our haulage arrangements, mainly direct rope or main and tail, and were designed to operate on the gradients which were met. Indeed, despite the increasing use of belt conveyors and locomotive haulages, many of the direct and main and tail rope haulages are still to-day the best and most economical in certain of the conditions of the British coalfields.

With the shortage of manpower, however, and with the increasing use of conveyors, or large-capacity mine cars and locomotive haulages, the case for level or near-level horizon roadways is much stronger, and at new collieries and most reconstructed ones this is the system which is being adopted.

The two methods of roadway drivage in the main present two entirely different mining problems. With the straight level horizon roadway the tunnel is driven in the solid strata with the objective of providing a main arterial roadway which will stand with little or no further repair work once the initial stress is taken by the supporting arches.

In the case of roadways driven in the coal seam it is also the practice in some instances where the roadways are to be main arterial roads, to tunnel in the solid. These tunnels are invariably driven ahead of the work of developing faces and extracting the seam and a supporting pillar of coal is sometimes left on either side of the tunnel to give settled support, thereby eliminating the need for constant and costly repair to the road during its working life. When the area of seam which the roadway is servicing is extracted and it can be abandoned, the supporting pillar of coal is then extracted on the retreat.

The most common method of roadway drivage in British mines in the past, however, has been to drive the roadways behind a leading or development face, the roadway being extended as the coal is extracted. The sides of the roadway from which the coal has been extracted are then packed with dirt to provide additional support. This method, although considerably cheaper than that of driving in the solid, does leave the roadway standing in unsettled ground requiring constant attention and repair.

The rates of drivage currently achieved generally range between 5 and 32 yards per week for tunnel sections ranging from 9ft wide by 7ft high to 16ft by 12ft. Isolated rates of up to 56 yards per week have been possible, however, in hard shale. Whilst none of these rates can be regarded as outstanding, it should be noted that the drivages in question were made in existing mines where the rate of drivage is largely controlled by the facilities available for disposing of the excavated materials. In many of these mines there is very limited transport and winding capacity, and priority has had to be given to the transport of coal, with the result that the rate of tunnel drivage has had to be scaled to the available capacity. Restrictions arising out of the Coal Mines Act and Regulations on the use of explosives within coal measures of course also reduce the rate of drivage in many instances.

It is estimated that about 3000 miles of tunnel will have to be driven during the next fifteen years in the execution of the industry's reconstruction programme quite apart from the considerable mileage which is driven in coal during mining operations every year, a distance which is equivalent to about four channel tunnels between England and France. This is a measure of the importance of seeking ways and means of speeding up work of this kind. Important investigations are therefore now being undertaken into the methods and machines used in tunnelling in the various formations found in the coal measures whereby the maximum effort can be concentrated at the face, consistent with the transport facilities available. Continuous tunnelling machines have already been developed on the Continent, but in their present form they are mainly useful in the softer types of strata. There is a real need for a machine which could deal with the harder types of rock often encountered in mine drivages, although this presents some very difficult problems. The required section of the tunnels is 16ft wide by 10ft high. If a circular tunnelling machine is developed it will need to drive a tunnel 18ft diameter.

Support of Roadways

In the matter of roadway supports, British mining engineers have traditionally favoured forms of support involving the use of steel arches and timber, which show visually the stresses and strains to which the roadways are subjected and which control, rather than resist to the point of failure, the unknown forces which are set in action when deep strata are disturbed by the tunnelling operations.

This practice is obviously necessary where mining operations are in progress, and where the maintenance of openings demands constant attention. In undisturbed areas, however, it is now becoming a more common practice to line tunnels with concrete at an increased initial cost with a view to eliminating subsequent costs on maintenance. This practice, however, is in the main confined to roadways within the shaft pillar or in horizon tunnels.

Over the years the method of supporting tunnels driven in the coal seams has changed with the development of new techniques and the increasing replacement of timber by steel. In the early days of extensive mining, the roadways were in the main supported by baulks of timber (pit props) " notched " or mortised one into the other and set into the wall of the tunnel at an angle to form an arch designed to resist to the maximum the distortion of the tunnel, while at the same time permitting the strata to " settle " uniformly without breaking the supports. The setting of these supports, the method of which varied from coalfield to coalfield to suit the particular conditions, represented an art acquired by the men concerned over many years, and it is to their credit that there are tunnels in British mines to-day which have stood supported by the original timbers, without the aid of nut or bolt of any description, for a quarter of a century or more.

In later years, the use of steel girders and arches has become more and more prevalent, and since the war there has been a marked increase in the use of yielding arches designed to submit to the initial crush of the settling strata without distortion.

The shape of the tunnel section calls for some comment. With the wide use of steel arches most of the main tunnels driven in the coal seams are horseshoe-shaped, but now that many of the main roadways are being driven through stone in various horizons and at much greater depths than before, the use of the circular shape commonly employed by civil engineers on permanent constructions is being considered in more and more mines, in certain cases in conjunction with concrete lining as mentioned previously.

With the adoption of rigid concrete linings the question arises as to when such linings should be constructed. Should it be done immediately following excavation or should some interval of time be allowed to elapse before the lining is constructed, using temporary steel arches for support in the meantime ? Although there is very little established knowledge on the pressures existing in rocks at depths, it is clear that some redistribution of stress takes place immediately an opening is made, and that the opening tends to become smaller with the passage of time. Whether this process continues indefinitely or reaches some degree of finality, is, however, debatable. It depends greatly on the size of the opening and the nature of the strata in which it is cut. Where prevention of movement is really important, as in the case of shaft pillars, the operation of tunnelling and lining must be carried out consecutively in short sections at a time, and this is the normal practice. The thickness of the lining used, in default of reliable data for calculation, must be based on past experience with similar works, adjustment being made for greater depths as is judged necessary. Many such works have been completed successfully, probably with an excessive " factor of ignorance," but until more information is known about rock pressures it would be unwise to make any reductions in the dimensions found satisfactory in practice.

Where the prevention of movement is of less

importance it is now being considered possible to drive much longer lengths of tunnel in advance of lining using temporary supports and thereafter to carry out the lining as a subsequent operation. This makes for speedier construction and it may also permit some reduction in the thickness of the lining used. A large proportion of the redistribution of stress in the surrounding rock will have taken place before the lining is done as a result of which the lining will have to carry only the disturbed zone material in its immediate vicinity. Comparatively thin linings have been used in roadways at a mine in Holland quite recently and although insufficient time may have elapsed to confirm their adequacy, experience to date has been satisfactory.

Transonic Tunnel Testing Technique

The Royal Aeronautical Society, on December 20, held an all-day meeting devoted to transonic wind tunnel testing techniques. Mr. H. F. Vessey, B.Sc., A.F.R.Ae.S., traced the historical development of vented walls and proceeded to the general principles of operation. We reproduce below part of his lecture.

THERE are four things that ventilating the working section of a closed jet tunnel can do for us :—

(1) Reduce (or eliminate) tunnel corrections at subsonic speeds or, alternatively, allow larger models to be used for the same corrections.

(2) Prevent choking at high subsonic speeds.

(3) Establish a uniform tunnel flow from a Mach number of, say, 0·8 to 1·4.

(4) Reduce or eliminate shock reflections at low supersonic Mach numbers.

Tunnel corrections have been exhaustively discussed in current literature. Briefly, most of the corrections for the various types of interference can theoretically be eliminated by the choice of the corret open/closed area in the working section or can be calculated by the use of approximations. Choking is avoided by almost any of the configurations which give reasonable transonic velocity distribution and in practice most of the effort is devoted to (3) and (4). The open area is chosen by theory, model tests and past experience to minimise corrections and then by experiment, aided by theory, the flow distribution is improved to the standard required. Typical values are 10 per cent open area for slots and 20 per cent for perforations.

The problems of flow establishment are best shown by typical curves, such as those of Fig. 1, which are taken from practice. The

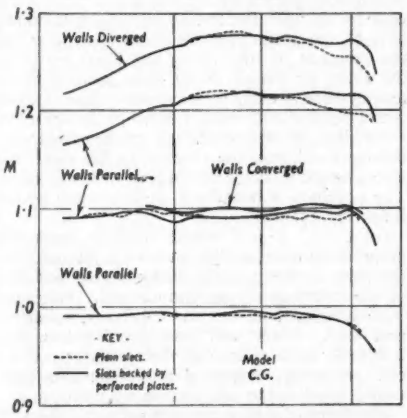


Fig. 1—Typical centre line distributions, R.A.E. 8ft by 6ft transonic tunnel

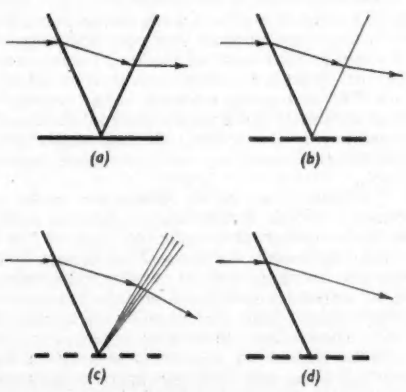
principle of the ventilated tunnel is to persuade the main stream flow to expand gradually and to form in fact its own supersonic nozzle. The porosity must therefore be graded, and for this reason slots are tapered and perforated walls have gradually increasing open area. The effect of too sudden an increase in open area is over-expansion at the beginning of the slots, causing a jump in Mach number, followed by a depression in a series of highly damped waves. This effect is avoided by establishing the correct taper.

At the rear of the testing length it is possible for the speed to drop off too rapidly. This can happen at subsonic speeds due to the pressure field from the support rig behind the model or at high subsonic speeds due to too low a pressure ratio from the main drive. At supersonic speeds the same effect can be given by the low shock from the support rig. The cure is obvious but not always easy to apply.

The curves shown were obtained by a centre line static survey in the R.A.E. 8ft by 6ft transonic tunnel.* The process of cut and try can be speeded up by tracing the disturbances back to the wall by putting in artificial disturbances by means of a step on the wall and observing where the effect shows up on the central static (they are not in fact transmitted at exactly the Mach angle). An over-expansion can then be cured by reducing the slot width or by inserting perforated plate behind the slot, in which case the effective blockage can be varied over quite wide limits by altering the angle of the perforated plate to the air flow.

Another powerful control on velocity distribution along the working section is provided by wall divergence, which should preferably be adjustable. At subsonic speeds without suction a small divergence is required to compensate for boundary layer growth. At transonic speeds a small convergence thins the boundary layer and reduces shock reflection, while at supersonic speeds convergence appears to have a stabilising effect on flow generation. Convergence does, however, increase the power required, and if the most is to be obtained from a tunnel it will be necessary to diverge the walls to reach the maximum Mach number and to accept some deterioration in distribution. For this reason the adjustable walls in the R.A.E. 8ft by 6ft tunnel will shortly be motorised.

I have left discussion of shock cancellation to the last, as this is probably the most controversial aspect of transonic tunnel design ; it certainly



(*a*) Solid wall, full reflection of shock wave.
(*b*) Open area ratio too small, weak reflected shock wave.
(*c*) Open area ratio too large, weak reflected expansion.
(*d*) Open area ratio correct, shock wave cancelled at wall.

Fig. 2—Shock wave reflection from perforated walls

leads to fierce arguments between the protagonists of slots and perforated plates.

The shock wave from, say, the nose of a model is reflected by a solid wall and at low supersonic speeds will strike the model again. This results in a change of pressure distribution and of the forces and moments. The mechanics of shock reflection and cancellation are shown in Fig. 2. The main cause of the reflection is the pressure rise on the wall due to the deflected flow behind the shock wave. If the porosity of the wall is such that the flow through it produces a pressure drop which is equal to the pressure rise through the main shock there will be no reflection, while if it is greater there will be partial reflection in the form of an expansion wave. (Expansion waves will be reflected in the inverse manner.) In a slotted wall tunnel shock waves will be reflected as shocks from the slats and as expansions from the open area, reflection is at a slightly different angle in each case and it will therefore be seen that unless the slots are very close there is little prospect of shock cancellation, although there may be some attenuation. With perforated walls, in which the holes are small in relation to the tunnel cross-section, conditions are improved, but as the theoretical open/closed area varies with Mach number and shock strength the answer must, at best, be a compromise, although it is claimed that acceptable results can be obtained over the working range by fixed wall porosity. It should be noted, however, that it is necessary to remove the whole of the boundary layer ahead of the shock or a complicated shock-boundary layer interaction causes shock reflection. Up to the present time we in this country have had little operating experience with perforated walls.

The choice between slots and perforations is a difficult one to make. Slots are claimed to be less difficult to install in an existing tunnel and to adjust for an acceptable velocity distribution. Perforations, on the other hand, promise some measure of shock attenuation but put up a pattern of a shock wave and an expansion wave from each hole which may extend into the model area. Goethert claims that perforated walls require less power than slotted, but bases this on a comparison of almost equal open areas. For practical operation slots require some half the open area of perforations and the powers then are much more equivalent.

The R.A.E. tunnels are slotted while A.R.A.'s tunnel† is perforated. When it can be arranged, comparative tests in the four large British transonic tunnels will provide extremely valuable data. These have been planned and will take place as soon as possible.

* THE ENGINEER, February 25, 1955, page 279.

† THE ENGINEER, May 11, 1956, page 479.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

GREY IRON CASTINGS

No. 1452 : 1956. Price 4s. This new edition of B.S. 1452 incorporates the result of experience with the 1948 edition. The principal alterations are : the making of the tensile test the basis of the specification, but for the control and regularity of product the transverse test may be substituted for the tensile test to a specified extent ; the introduction of a test sample for large and/or heavy castings as an alternative to the use of very large test bars ; amendment of the deflection requirement in the transverse test, this figure now being required only for the higher grades as an indication that the material has some improved impact resistance as compared with the lower grades ; amendment of the radius of the end of the parallel length of the tensile test pieces, to facilitate machining. An interesting feature of the revision is an appendix which shows, in the form of a graph, the strength that might be expected in different running thicknesses of the same casting.

METHODS OF TESTING VULCANISED RUBBER

No. 903, Parts C1 and C2 : 1956. Price 3s. 6d. each. Under this revision of B.S. 903, Part C1 is for the determination of surface resistivity and Part C2 is for the determination of volume resistivity of insulating soft vulcanised rubber and ebonite. The group of parts in which the prefix letter "C" is used deals with methods of testing the electrical properties of rubber and ebonite. Parts C1 and C2 replace Sections 33.2 and 33.3 respectively of the 1950 edition.

The methods differ from those in Part 33 of B.S. 903 : 1950 in that they include an electrometer method and provide for an alternative test voltage. Both parts give details of electrodes and the various types of apparatus and procedure. A method for the calculation of results is also given.

Metallurgical Topics

Scoring and Surface Damage

A STUDY has been made, by A. E. Roach, C. L. Goodzeit and R. P. Hunnicutt, of the General Motors Corporation, Detroit, of the resistance to scoring of thirty-eight metals in high-speed gliding contact with 0·45 per cent carbon steel discs.[1] Resistance to scoring, galling or seizing is a property of great practical importance in bearings, piston rings, shaft-ends, gears and all parts that rub together. It is an indication of the ability of materials to slide against one another without welding or otherwise sticking together. The metals were tested in the form of slider bearings, ¼in by ¼in, pressed at an angle of ½ deg. against the face of a 0·45 per cent steel disc. The disc was rotated at 5400 r.p.m., giving a sliding velocity of 4640ft per minute. Loads applied varied from 0 lb to 1200 lb. Lubrication was provided by a fine stream of kerosene (2·7 cc per second) sprayed upon the hub of the disc. The lubrication was at best partial, since electrical resistance measurements across the kerosene film indicated that metal-to-metal contact occurred at all loads. The load-carrying ability was used as a criterion for resistance to scoring. The metals were arranged in four different categories on the basis of an elimination procedure which involved testing at three different loading conditions of increasing severity. The four groups were as follows :—

Very Poor Scoring Resistance Against Steel.—All metals which failed in the first or least severe test in which the load was increased uniformly from zero to 300 lb at a rate of 4·35 lb per second.

Poor Scoring Resistance Against Steel.—All metals which passed the first test but failed in the second test, in which the load was maintained constant at 300 lb for one minute.

Fair Resistance to Scoring Against Steel.—All metals which passed the first two tests but failed in the third test, in which the load was maintained constant at 500 lb for one minute.

Good Resistance to Scoring Against Steel.—All metals that passed the 500 lb constant load test.

At least four different tests were made with each metal (except some of the precious metals like rhodium and iridium), a new slider bearing and disc being used for each test. Generally there was excellent agreement, but a few metals showed erratic or marginal behaviour. Cadmium, mainly good, and copper, mainly poor, were sometimes fair. Table I shows the thirty-eight metals as classified by these tests.

TABLE I—*Resistance to Scoring Against 0·45 Per Cent Carbon Steel (Roach, Goodzeit and Hunnicutt)*

Good	Fair	Poor	Very poor
Germanium	Carbon	Magnesium	Beryllium
Silver	Copper	Aluminium	Silicon
Cadmium	Selenium	Copper	Calcium
Indium	Cadmium	Zinc	Titanium
Tin	Tellurium	Barium	Chromium
Antimony	—	Tungsten	Iron
Thallium	—	—	Cobalt
Lead	—	—	Nickel
Bismuth	—	—	Zirconium

Very poor (*continued*): Niobium, Molybdenum, Rhodium, Palladium, Cerium, Tantalum, Iridium, Platinum, Gold, Thorium and Uranium.

When the resistance to scoring was good, the only evidence of sliding contact was polishing of the edge of the slider bearing where contact had been made with the disc, and a corresponding polishing of the disc along the circumferential track of contact with the slider bearing. Examination of slider bearing and disc under the microscope showed no evidence of metal transfer from the slider bearing to the disc or vice versa.

When there was very poor resistance to scoring, both slider bearing and disc suffered extensive grooving, tearing and metal transfer. With such materials failure was manifested by sudden stoppage of the disc due to seizure of the bearing, or by the sudden appearance of bearing metal transferred to the disc and accompanied by rapid heating, evolution of kerosene vapour and smoke, or in some instances by showers of sparks and flames.

Correlation of Results with Other Properties

In correlating the results of these tests with other properties of the metals, the authors concluded that the only metals that had satisfactory scoring resistance against steel in the slider bearing tests were those metals of the "B" sub-group of the Periodic Table that are immiscible with iron, or that form intermetallic compounds with iron. All other metals had an unsatisfactory scoring resistance against steel.

The fact that the scoring resistance of metals sliding against steel was related to their position in the Periodic Table of the elements was first observed by A. F. Underwood, who noted that the metallic elements known to have good scoring resistance against steel were found in the odd-numbered rows of Mendeleef's table, i.e. the "B" sub-group metals. Mutual solubility of bearing and journal has also been suggested as a factor in seizing; and in static friction, also, the best metal pair has been found to consist of metals that are immiscible. It was now found, from the tests outlined above, that :

"B" sub-group metals that are immiscible with iron in both solid and liquid states had a good resistance to scoring.

"B" sub-group metals that have extensive solid solubility for iron had poor to very poor resistance to scoring (copper, however, being rated "fair" in some tests).

"B" sub-group metals that form intermediate phases with iron had either good to fair or poor scoring resistance, depending on the character of the intermediate phases. When the intermediate phase is a definite intermetallic compound, the scoring resistance was good to fair. When the intermediate phase is a solid solution, the scoring resistance was poor.

Both conditions ("B" sub-group and immiscibility or intermetallic compound) were shown to be necessary to characterise metals with a good scoring resistance against steel. Thus, copper, zinc and gold, which are "B" sub-group elements but show some mutual solubility with iron, have poor or very poor resistance to scoring, as also have magnesium, calcium and barium which are immiscible with iron but are not "B" sub-group elements. All the metals that were rated good against steel satisfied both conditions; conversely, all the metals that satisfied both conditions were rated good against steel.

The authors go on to discuss the results in relation to the forces which bind the metal crystals together, and to the fact that the "B" sub-group metals are thought to possess both metallic bonding (which is mobile) and covalent bonding (which is rigid and tends to brittleness). They suggest that the solubility of a pair of metals determines the number of junctions that will be formed on an atomic scale when the metals slide, and that the periodic grouping determines the character of those junctions. Even though calcium and barium are immiscible with iron and form few junctions on an atomic scale, they are "A" sub-group metals and it may be that the bonding of the junctions is largely metallic. Because of the mobility of such bonding it gives a junction which tends to wipe and smear rather than break cleanly, and in this way is conducive to the formation of still more junctions. With "B" sub-group metals the bond to iron may not be wholly metallic. It may be appreciably covalent and, if so, this may be significant in giving a more brittle and easily broken junction, and a better scoring resistance against steel.

These ideas were put forward in a tentative way, subject to further confirmation. The possible influence of oxide films was referred to in the discussion, but the capacity to form protective or non-protective films bore no relation to the rating of the various metals in these tests, in which oxide films may play a lesser part than in low-speed tests without lubrication. However, it was agreed that tests in hydrogen might strengthen the proposed interpretation of scoring behaviour.

Frictional Characteristics and Surface Damage

The same authors have reported upon the frictional characteristics and surface damage of thirty-nine metals in sliding contact with Armco iron, at slow speed and without lubrication.[2]

Moving parts are designed to operate ordinarily with lubrication; and friction, under these conditions, is virtually independent of the coefficients of friction of the metals used. It is rather during periods of momentary distress involving insufficient lubrication, or excessive speed or overload that the use of suitable metals becomes of great importance; and then it is desirable that the metal used should not seize or gall or otherwise suffer surface damage. Accordingly, the purpose of this investigation was to ascertain and present such information on surface damage characteristics as might be useful to engineers and designers, rather than to measure coefficients of friction.

The tests were made with the same metals as before in a Bowden-Leben type of apparatus.[3] A flat plate specimen mounted on a carriage moves horizontally at a slow rate and a rider (a cylinder with a hemispherical end), attached to a cantilever beam, is in contact with the plate specimen. In these experiments the plate consisted of a specimen of the metal and the rider was of Armco iron. Surface damage was evaluated in two ways : (*a*) by comparing photo-micrographs of the surfaces of rider and plate before and after testing, and (*b*) by examination of the surface of the plate specimens for the presence of iron along the track made by the rider, by means of an electrographic spot-testing method using gelatin-coated paper soaked with a reagent containing potassium ferricyanide. Four kinds of surface damage to the plates were distinguished, and the damage to the rider was also assessed as being one of four different kinds. The extremes of behaviour are illustrated by the following examples :

(*a*) Little, if any metal transfer from the plate to the rider, and no metal transferred from the rider to the plate, shearing having occurred at the interface of metallic contact. Examples were selenium, silver, tin, antimony, tellurium and lead. Silver and lead dissolve less than 0·001 per cent of iron at their melting points; tin, antimony, selenium and tellurium form well-defined stable compounds with iron.

(*b*) Track on plate poorly defined, pieces of rider metal welded to asperities on the plate : contact area on rider well defined with the original asperities levelled off. Examples were beryllium, chromium, manganese, cobalt, nickel, molybdenum, tungsten and iridium, all of which are miscible with, and harder than iron. The shearing process occurred in the iron. In general, the strength of the metallic junction between two miscible metals in sliding contact is greater than that of either of the metals themselves.

The results of these experiments have a bearing on what may be good or bad in practice. Silver, for example, has been successfully used as a coating to reduce surface damage on separators for high-speed rolling contact bearings. The good behaviour of tin and lead, and the tendency of nickel to seize, in sliding contact with iron are well known.

In agreement with Bowden and others, the authors concluded that the surface damage suffered by metals in sliding contact was a

consequence of the formation and shearing of welded junctions ; but they go on to refer to their previous conclusions about immiscibility or ability to form intermetallic compounds with iron. The same general correlation was found in the present friction and surface damage tests as in the previous high-speed gliding contact tests. There were no soluble metal pairs that gave shearing at the interface with no surface damage. With all soluble metal pairs shearing occurred in the plate specimen metal or in the rider metal or both. The location of the plane of shearing in relation to the interface was determined by the relative hardness of the metals. Metals giving rider damage (metal transferred from plate to rider, but little, if any, metal transferred from rider to plate specimen), all had an indentation hardness less than that of Armco iron.

No simple direct connection was found between the surface damage suffered by the various metals and the value of their coefficients of sliding friction.

Comment on the Solubility Hypothesis

It appears that correlation of surface damage with mutual solubility is an over simplification of the problem. In the discussion of the paper, Drs. F. P. Bowden and D. Tabor, while agreeing that at high speeds of sliding, when frictional heating may be sufficient to produce surface melting, mutual solubility of the sliding materials will influence the surface damage, found it difficult to see how mutual solubility could be of importance at the very low speeds of sliding used in the authors' work, in which the temperature rise could be only of the order of a few degrees Centigrade. The final classification of the surface damage appeared to support the authors' hypothesis, but many other physical and chemical properties provided a similar classification. In their experience the sliding process between unlubricated metals depended in a critical and complex way on a number of physical properties and conditions. Mr. L. Grunberg, also, raised the question as to whether diffusivity, a time-dependent operation, would not be a better criterion than solubility. The authors agreed, but stated that in view of the relative absence of data on diffusivity they had used mutual solubility as an indication of tendency to diffuse. Metals with strong alloying tendency tended to form strong junctions, whereas weak junctions were formed by metals of low alloying tendency or by those which tend to give brittle and friable intermetallic compounds.

References

[1] *Trans. Am. Soc. Mech. Engrs.*, November, 1956, page 1659.
[2] *Ibid.*, page 1669.
[3] *Proc. Roy. Soc.*, Series A, Vol. 169, 1939, page 371.

Metallurgical Uses of Sodium

The latest of the American Chemical Society's series of Chemical Monographs is devoted to *Sodium : Its Manufacture, Properties and Uses.** Though the text is mainly concerned with chemical matters there are extensive references to the metallurgical and engineering applications of sodium. The outstanding engineering application is the use of sodium as a heat-transfer medium. For this purpose it has many advantages. Its heat-transfer coefficient is among the highest known, and it has the advantages of extreme thermal stability and a high boiling point (892 deg. Cent.). It will therefore withstand a very considerable rise in temperature without involving greatly increased pressure. On account of its low density the power requirements for the circulation of the sodium-potassium alloy is less than half that required by the lead-bismuth alloy, which is also available as a heat-transfer medium.

The use of sodium as a heat-transfer medium in sodium-cooled valves for internal combustion engines has long been known. The first references to the application of sodium for this purpose appeared in 1928. In this way sodium serves the metallurgist indirectly by reducing the operating temperature and so prolonging the life of the valves. Sodium-potassium and sodium-mercury alloys may offer advantages as heat-transfer media because of their lower melting points, and both have been used as coolants in engine valves.

In the manufacture of magnesium alloy die castings, water cooling of moulds is undesirable because of the possible contact between water and the hot magnesium. Sodium has been used to control the temperature of the casting head, and this control by liquid metal may be expected to increase the life of dies and the output of the die casting machines. More important, however, is the method of cooling the cores. In one plant sodium has been used to partly fill the chromium-molybdenum steel cores which moved from a vertical to a horizontal position during the casting cycle. The sodium gave rapid heat transfer from the bottom to the top of the cores, prolonging the core life and permitting faster operation of the die casting machine. There are many actual or proposed uses of sodium for heat-transfer purposes in the fuel oil industry, in glass manufacture and in power plants, but its outstanding future application in engineering is in nuclear power plants. It has applications, also, in electrical industry. The sodium vapour lamp is well established. On account of the excellent electrical conductivity of sodium (exceeded only by that of copper, silver, gold and aluminium) steel pipes filled with sodium have been used as busbars in an electro-metallurgical plant. Alloys of sodium with barium or calcium produce photo-electrically sensitive elements for use in photo cells. On a laboratory scale sodium has been used as a heat-treating medium. In an apparatus built up of concentric thin-walled stainless steel tubes a sodium-potassium alloy has been used both for external heating and as an immersion medium, giving uniformity of temperature to less than 1 deg. Cent. over a length of 2ft.

Of the purely metallurgical applications of sodium, one of the most important is its use in the " modification " of aluminium-silicon alloys. The addition of a small amount of sodium to aluminium-silicon alloys with 11 to 13 per cent of silicon suppresses the separation of crystals of silicon and converts the coarse brittle structure of the cast alloy into a fine grained structure with greatly improved mechanical properties. Claims have been made for the use as bearing metals of sodium-lead alloys containing other elements in addition. These other elements range from calcium to aluminium, copper and tin, and it may be suspected that any advantage the alloy may possess is due mainly to these additions. For example, the German Bahn-metal, used in railway axle bearings in Germany in the 1930s, contained 0·75 per cent of calcium as well as 0·5 per cent of sodium, and it seems likely that its properties were dependent on the separation of hard particles of Pb_3Ca rather than on any effect due to sodium other than its influence on the surface tension of the liquid metals during the production of the alloy. Its effect on the surface tension or " wetting power " of liquid metals has led to numerous suggestions for the use of sodium as a minor component of various metal coating compositions. Sodium reacts vigorously with metal halides, and titanium, thorium and uranium have been made from their chlorides or fluorides by reduction with sodium in a closed steel vessel, but this process has been replaced by other, more convenient methods of reduction, except possibly in the case of tantalum, which is (or was until recently) made by reducing potassium fluoro-tantalate with sodium.

Much work, reflected by an astonishingly large number of published papers and patents, must have been devoted to the use of sodium as a deoxidising and desulphurising agent, but actual applications of metallic sodium for those purposes are rare. On the other hand, great use is being made of caustic soda, sodium salts or compounds of sodium in such operations as the removal of arsenic and antimony from lead in the lead refining process, the desulphurisation of molten iron by soda ash treatment in the ladle, and the sodium hydride method of descaling, applicable to any metal or alloy which does not react with molten caustic soda and whose mechanical properties are not adversely affected by a bath operating at 350 deg. Cent.

* Published in this country by Chapman and Hall, Ltd.

Beryllium Copper

Beryllium copper is used for springs, contact clips and parts of electrical machinery requiring very good mechanical properties and moderately high electrical conductivity. These applications are based on the discovery by Masing in 1926 of the pronounced precipitation hardening of the copper-beryllium alloys. The solubility of beryllium in copper is 2·1 per cent at 854 deg. Cent., falling to 1·4 per cent at 576 deg. Cent. and then more rapidly to 0·2 per cent at 300 deg. Cent. The hardening treatment was a solution annealing at 800 deg. Cent. and reheating the quenched alloy at 250 deg. to 350 deg. Cent. to precipitate particles of the γ constituent in the α solid solution ground mass.

When beryllium copper was introduced commercially its beryllium content was 2·5 to 2·75 per cent. The course of development of the binary alloy is traced by J. T. Richards in an article in *Iron Age*, November 8, 1956, page 95. As the alloy was more widely produced, a lack of uniformity of properties, due to uneven distribution of the precipitated phase was observed. It sometimes happened that the two ends of the same coil might require different treatment to

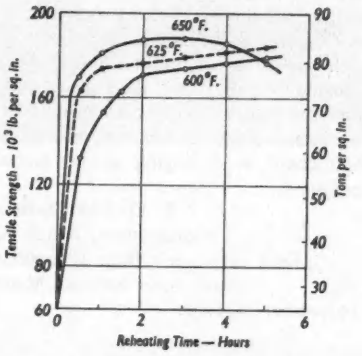


Fig. 1—Ageing curves for annealed beryllium copper strip at temperatures from 600 deg. to 650 deg. Fah. (315 deg. to 343 deg. Cent.)

give the same hardness. It was found that the addition of small amounts of nickel or cobalt retarded grain growth during annealing and resulted in greater regularity in the results of heat-treatment. The beryllium content has been gradually reduced since the alloy first came on the market. Originally, 2·5 per cent, it was decreased to 2·25 per cent in the early 1930s, to 2 per cent during the war, and to 1·9 per cent in 1951. In the binary alloy no useful degree of hardening can be produced if the beryllium is 1·5 per cent or less, though with the addition of 1 to 3 per cent of zinc or tin the alloy still retained its precipitation-hardening character when the beryllium was reduced to 1·1 per cent. The standard alloy, however, contains not less than 1·9 per cent of beryllium. It is important economically that the ageing time, or time of reheating, of the alloy should not exceed three hours, and it was found that with decrease in beryllium content a higher ageing temperature was required to ensure development of maximum strength within this time limit. The 1·9 per cent beryllium alloy requires ageing for three hours at 650 deg. Fah. (343 deg. Cent.) instead of at 600 deg. Fah. (315 deg. Cent.), which is suitable for the 2·5 per cent beryllium alloy. Fig. 1 shows the effect of reheating on the 1·9 per cent beryllium alloy strip after solution treatment. The maximum strength is developed after three hours at 650 deg. Fah., but at 600 deg. Fah. eight hours would be required to attain the highest tensile strength. Half-hard and hard strip (obtained by cold working the alloy in the solution treated condition before ageing) achieve a maximum in tensile strength when reheated for two hours at 625 deg. Fah. (329 deg. Cent.) instead of the same time at 600 deg. Fah. as required for the alloy of higher beryllium content.

Progressive reduction in beryllium content, such as has been going on over a long period, has not only effected a saving of beryllium, but has given a more ductile and workable material, especially suitable for deep-drawing operations.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

WELDING AT CALDER HALL

SIR,—In your edition of October 5, on page 465, you have an article on the Calder Hall Power Station. In this article there is a statement that 2in was the maximum thickness of metal reasonably welded on site subject to radiographic examination. This statement has caused some interest in the U.S. Navy Department and some concern to me. The U.S. Navy commonly have 4in or 6in thick pressure vessels welded on site. Your statement seems to indicate that the art of welding in the U.K. is rather backward, or else there are very good reasons for reducing the weld thickness on site to 2in, which you do not mention. Your estimable magazine is read all over the U.S.A., and the article on Calder Hall has naturally been of great interest, but the inference in this paragraph could be damaging to our technical prestige.

P. D. TATTON-BROWN
Commander, Royal Navy
Staff Engineer Officer (Propulsion),
British Joint Services Mission.
November 16, 1956.

Literature

Selection and Training of Foremen in Europe. By SVEN GRABE and PAUL SILBERER. The Organisation for European Economic Co-operation, 2, Rue André-Pascal, Paris, Price 12s. 6d.

THIS book consists of a report by two experts in the International Labour Office, made at the request of the European Productivity Agency of the Organisation for European Economic Co-operation, and is based on the best practices to be found in the countries surveyed, and accordingly should be a challenge to manufacturers and industrialists as to how far they are conforming to the best principles in the selection and training of the foremen they employ.

The first chapter is entitled " The Position, the Man, and the Job," and in it is the suggestion that the new foreman should be characterised by leadership, have a recognised social status, and possess the necessary qualifications to be efficient in his post. The second chapter deals with his selection and the schemes evolved to ensure getting the best man, while the third chapter is concerned with his training, its objective, and the subjects to be taught, both to potential and to existing foremen, this very training to be a definite policy of the undertaking. The fourth chapter is devoted to research and organisation, and international co-operation, and the fifth and last chapter gives us clearly a summary and the conclusions arrived at by the investigators. A valuable appendix, occupying fifty-two pages, gives details of the means for the selection and training of foremen that have been adopted in Austria, Belgium, Germany, Greece, Italy, the Netherlands, Norway, Sweden, Turkey and, last but not least, the United Kingdom. It would have been helpful if a summary of the findings could have been presented in tabular form so that comparison between countries might be facilitated. A second appendix gives a list of those publications that might be of particular interest to readers of the report, while a third explains the methods used in the survey, followed by a list of the principal contacts made with the firms and organisations in the ten different countries visited. Such is a brief outline of the contents of a book that is calculated to be of value and interest to foremen, prospective supervisors and management generally.

After carefully reading the report, the first impression is that the ancient adage *quot homines tot sententiae* is a very true one, but at the same time there would appear to be perfect agreement that it is essential for a foreman to have an understanding of human relations, and also to have the status necessary to carry out his duties, which entails that he must have an adequate salary well above the wages earned by the pieceworkers responsible to him. There would seem to be an increasing systematic organisation of the promotion and recruitment of potential foremen, in view of the higher turnover of personnel, and shortage of skilled workers. When questioned as to qualifications looked for in a man considered for promotion, managers were by no means of one mind, some thinking he should be a first-class craftsman, others that he must be a born leader, while a few even considered that he should possess a knowledge of foreign languages. While this latter might apply to some countries on the Continent, it is hardly likely to be regarded as a necessity in this country. On the question of selection it was found that the use of systematic procedure, and guidance in the beginning of courses for potential foremen tended to eliminate a number of failures, and to raise the standard. Firms generally realise that selection of suitable men must be preceded by suitable training, and where possible by working as deputies to existing foremen. The question of training is one that is increasingly receiving attention, as it is realised that foremen must possess an education superior to that of most of their team, but what form that teaching should take is very debatable, and must probably be governed by local conditions. While training schools for mechanics and apprentices have generally met with success, the training of existing foremen presents more difficulties in that the older men, though admittedly having far more experience than their younger colleagues, are afraid of the competition of young men, whom they imagine may be quicker in apprehension, and perhaps liable to supplant them in their posts. This difficulty can be overcome to a large extent by a frank talk prior to the beginning of the classes. While the necessity for " drawing out " of foremen is stressed as well as the advisability to become less conservative, and better to appreciate policies, we are surprised that the value of arranging visits to other works has not been mentioned. The photograph of the residential college of the Finnish Foremen Training Institute shows the extent to which some countries have gone, while another photograph is of particular interest in that it illustrates " learning to learn " and shows a number of Turkish foremen being taught how to analyse jobs, and to take notes before going on a two months' study. It is felt that this is an excellent procedure, for too often foremen fail to benefit as much as they might by the very fact that they have not the gift of taking good notes, and are quite unable to write a satisfactory report.

It is perhaps the conclusions reached by the investigators that are of the greatest value for, as is rightly affirmed, " a new concept of the role of the foreman is developing in European countries." He is now generally looked upon as part of the management and brought more into the policy of the undertaking, his status has materially improved, as is evidenced by a more suitable salary. It is contended that he must have been selected carefully, that he must have been given adequate training before and after selection, while his functions must be clearly defined and the principles of leadership duly inculcated in him.

The modern idea of indicating everything by letters has been followed throughout and though most would know that TWI indicated training within industry, not so many would recognise that ILO, which is frequently referred to, means international labour office, or NIIP National Institute of Industrial Psychology. Admittedly, the name is given in full when first mentioned, but it is suggested that a list of these abbreviations might with advantage be incorporated with the index, for easy reference. This investigation into the selection and training of foremen in Europe is a valuable contribution to an important study and may well be read by foremen, would-be foremen, indeed, all engaged in managerial problems.

Electronic Computers, Principles and Applications. Edited by T. E. IVALL and published by Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 25s.

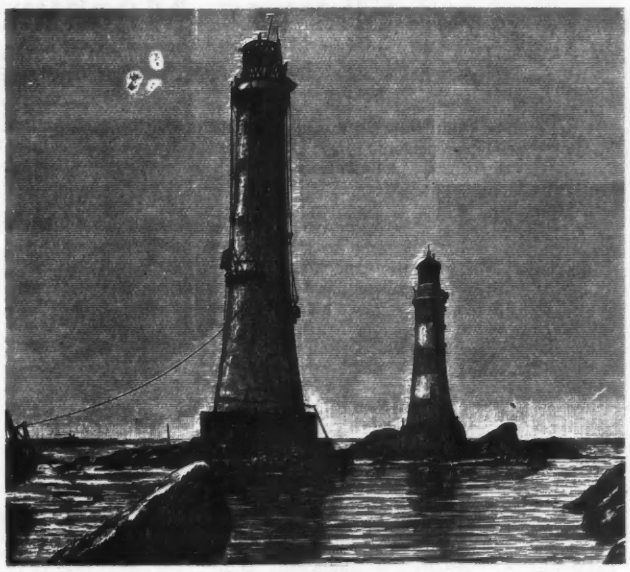
THIS is a *Wireless World* publication and has the great merit of being written in English that is easy to read. It is an unambitious compilation, but attains its purpose of presenting in non-technical language an interesting and reasonably broad picture of digital and analogue electronic computing. It traces the history of their development, the theory of binary numbers, and outlines the basic electronic elements now in use.

The simpler things such as binary addition are simply explained, but when it comes to more complex matters the explanations are very sensibly omitted, and functional statements substituted. The non-technical reader need not be dismayed as some idea of what is implied in physical hardware is also given by some exceptionally fine photographs of British computers. These photographs place especial emphasis on Britain's computers as only one foreigner is included. Illustrations relate to the digital computers of the British Tabulating Machine Company, Ltd., Elliott Bros. (London), Ltd., Ferranti, Ltd., J. Lyons and Co., Ltd., and the National Physical Laboratory, and the analogue computers of Short Brothers and Harland, Ltd., Saunders-Roe, Ltd., and the Royal Aircraft Establishment : this list is not exhaustive.

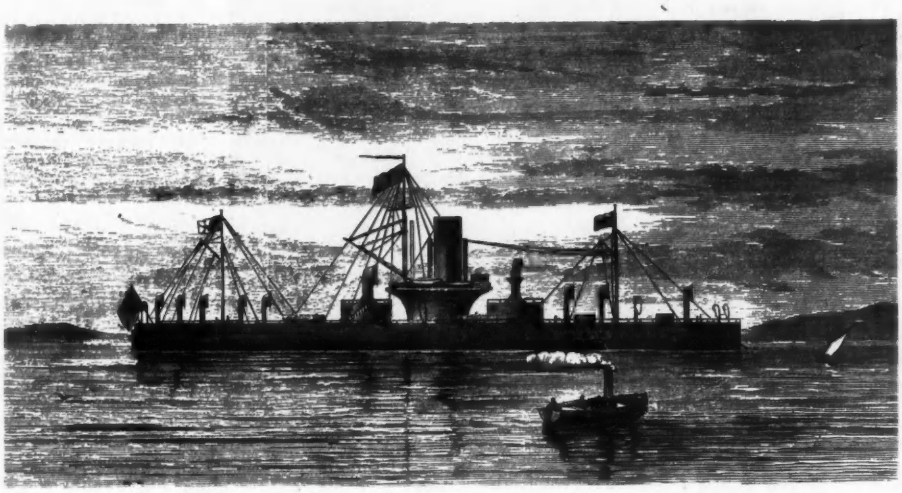
No computer book is complete without a chapter on applications and a forecast of the future. This one is no exception. The data on applications is sound and down to earth. The editor's choice of a machine for the future is a machine that can " learn." This book can be recommended as an introduction to the subject for the beginner.

ENGRAVINGS OF 1881

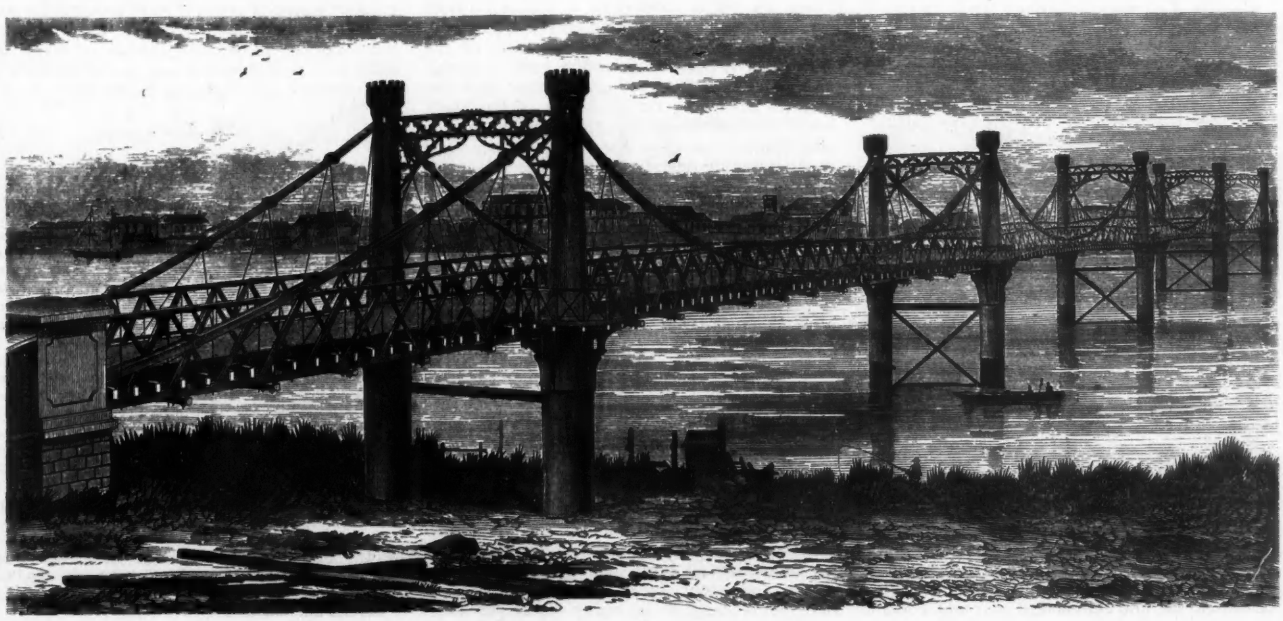
In our issue of December 9, 1881, there was published "a view of the new and old Eddystone lighthouses taken from a photograph by Messrs. Long and Co., Plymouth." That view is reproduced in the right-hand engraving. About it, we said: "the last stone was laid by Mr. J. N. Douglass, M.I.C.E., the engineer for the work, in May last; two thousand two hundred stones from the De Lank quarries and High Tor have been used, weighing altogether 6000 tons. The view shows the general features of the tower very clearly. The system of construction is very similar to that adopted in the original structure."



Below, there is reproduced from our issue of July 8, 1881, an engraving illustrating the "Peter the Great," which was at the time reckoned to be "the largest and most formidable warship of the Russian Navy." We explained that the ship was "lying in the Clyde, off Greenock, where she arrived from Cronstadt, under command of Captain Vladimir Basargean." Our article goes on to say: "the 'Peter the Great' and the 'Minin' are the two mastless turret-ships of the Russian fleet of war-vessels, resembling in design those of the same type of our own navy, the 'Dreadnought' more especially. Preparations are being made for the reception of the 'Peter the Great' by Messrs. John Elder and Co., who are about to replace her present machinery, which has proved unsatisfactory, with that of higher power and improved construction. The 'Peter the Great' was built in Russia ten years ago, at the Admiralty Works, Galleray Ostroff, St. Petersburgh, and her engines constructed by Mr. George Baird, a Scotch engineer, at St. Petersburgh, from the designs of Mr. Norman Scott Russell."



The engraving below illustrates the Fitzroy Bridge, Rockhampton, Central Queensland. It is reproduced from our issue of November 4, 1881, in which we described it as "a fine suspension bridge, 1104ft long, in four main spans of 232ft, and two end spans of 88ft." The piers, we said, were "made of cast iron columns, the chains of wrought iron. The bridge was opened on the first day of the present year."



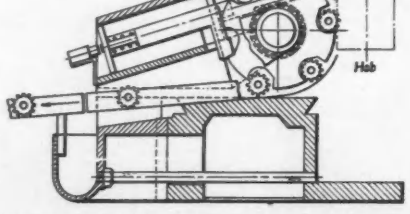
Automatic Cycle Gear Hobbing and Shaving Machine

PARTICULARS of the equipment developed for the automatic loading and control of the "Hydrax" No. 7 gear hobbing machine and the "S6H" gear shaving machine have been issued by the David Brown Machine Tool Division, Sherborne Street, Manchester. The "Hydrax" high-production hobber is designed for cutting gears up to 7½in diameter, and it can readily be converted from a hand loading to a fully automatic repeat cycle operation machine with the equipment shown in the accompanying illustration. The equipment consists of a blank indexing unit which is operated from the hydraulic system of the machine, an additional hydraulic sequence valve, a fine adjustment control valve and two additional switches. With it gear blanks can be fed in small quantities to the indexing plate by a simple chute or, if more convenient and practicable, by the addition of a vibratory bowl type feeder unit.

The loading plate, to be seen in the drawing we reproduce, has six stations, and in each machine cycle this plate is indexed through 60 deg. and automatically picks up a gear blank which falls by gravity from the chute exit. At the end of a cutting cycle the incoming blank is carried to an intermediate position between the loading and cutting stations, then, at the end of the second cycle after the blank enters the indexing plate, it reaches the cutting position. When in this position the mandrel mounted on the hydraulic tailstock passes through the bore of the gear and is gripped by a collet in the driving spindle.

After cutting, the gear is indexed to a further intermediate position from which it is prevented from falling by the lip of the exit chute. On completion of the next cutting cycle this gear is automatically pushed down the chute by the plate and the empty station takes up the intermediate position to the blank collection point.

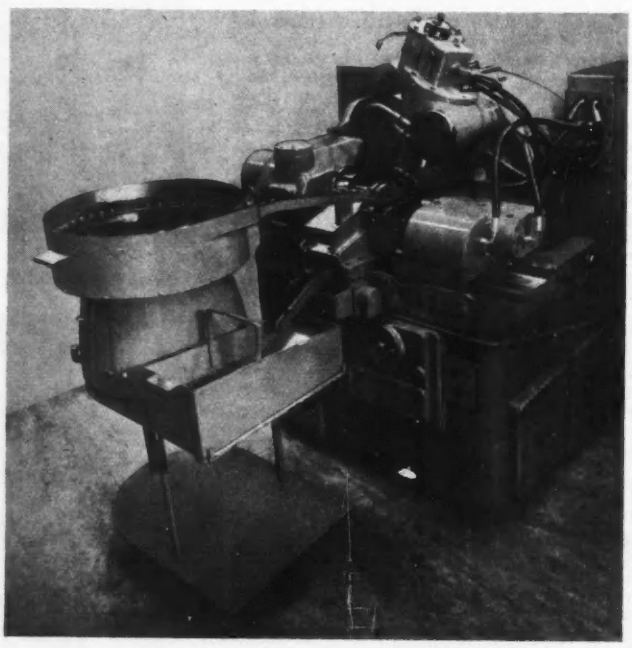
The loading plate is indexed by a rack and pinion, the rack being integral with a hydraulic piston which imparts a linear movement equivalent to one-sixth of a revolution of the plate. The final positioning of the plate is determined by a spring-loaded stop. On completion of a cycle, the rack piston is retracted until a limit switch at the back of the loading fixture is contacted. This switch starts the reloading process. The sequence of operation of the hydraulic tailstock and spindle collet is synchronised with



Arrangement of indexing feed plate on gear hobbing machine arranged for fully automatic repeat cycle. The plate has loading, cutting and discharge stations with the three intermediate positions and is actuated by a hydraulic cylinder

the loading action in such a way that when a predetermined pressure has been reached in the cylinder a pressure switch is actuated to set the cutting cycle in operation once again.

With the machine set for single-cycle operation it is possible to index the loading fixture by means of push buttons, so that before the automatic cycle commences, the first gear blank can be rapidly brought into the loading position. On the automatic start button then being depressed, the hob commences to rotate, coolant is supplied and the cutter head plunge feeds into depth. On the cutter head reaching full depth a slight delay is arranged by hydraulic sequence in order that at least one revolution of the workpiece takes place before the cross traverse starts. On completion of the cross traverse the main and coolant pump motors stop, the cutter head withdraws and the hob returns quickly to the start position. The collet then automatically unclamps, the work mandrel withdraws and the piston rack on the loading fixture retracts.



"Hydrax" gear hobbing machine, fitted with automatic loading and control equipment and using a vibratory feed bowl

This in turn operates the limit switch which institutes the indexing of the next blank to the cutting position, together with the clamping sequence. At any time during the cutting cycle it is possible to change over to repeat cycle operation. In this case, subsequent machine cycles are set in motion by a pressure switch operated on completion of the clamping sequence.

During the repeat cycle operation of the machine it is possible to switch back to single-cycle operation at any time. In this event the machine completes the operation of the blank being cut, then automatically unclamps, reloads and clamps, but does not restart. Each time the unclamping operation takes place the hob is automatically moved a predetermined increment of shift; when the hob has traversed the full amount of preset shift the machine automatically stops, and a red indicator lamp lights up.

The hobbing machine with automatic loading illustrated has been built for the Fiat Company of Italy for cutting helical oil pump gears. These gears have ten teeth, 3mm module (normal); 10 deg. helix angle, right and left hand, and 25 deg. (normal) pressure angle. Depth of the tooth is 0·286in and the face width 0·409in. The material from which the blanks are produced is S.A.E. 1030 having a hardness of between 170 and 217 Brinell.

With this set-up, a 4in diameter by 4in long single-start, high-speed, steel ground thread hob running at 242 r.p.m. gives a cutting speed of approximately 250ft per minute. The plunge feed is 0·060in and the cross feed 0·12in respectively per revolution of work. Climb cutting is employed and under these conditions the production rate is stated to be eighty pieces per hour. With hob shift taking place at the end of every cycle this production rate is obtained with an average of 300 pieces per regrind of the hob.

To convert the standard "S6H" shaving machine for automatic loading automatic work centres must be provided, and these centres are operated by the hydraulic unit of the machine. Whilst the shaver is designed for conversion to fully automatic repeat cycle operation, this conversion is carried out by the manufacturers during assembly, since it is desirable that the additional equipment should be designed and fitted to a machine to suit the particular gear that is to be produced. The automatic loading equipment is of similar design to that for the hobbing machine with the exception of the dividing plate, which is designed to ensure that the hobbed gears do not jam with the cutter during the indexing process.

In bringing the first gear to the shaving position the loading sequence is the same as that for hobbing. On operation of the automatic start button the cutter commences to rotate, the head feeds in the initial distance of 0·010in which is allowed for loading with backlash, the coolant supply is switched on and the cutter is traversed across the gear. The cycle continues until the set number of passes has been made. It should be mentioned that any number of cutting passes, in increments of 0·001in, 0·002in or 0·003in, can be made up to a total movement of a further 0·010in, after which any number of idling passes may follow before the machine is brought to rest, the number of passes being preset on an electrical counter.

It is pointed out that with fixed centre shaving on the machine no actual infeed motion of the cutter takes place with the exception of the initial 0·010in movement before the cross traverse starts. The advantage of this method is that backlash already exists in the loading position, and when using the oblique method of shaving only a minimum cross traverse is required.

Depending on the design of the gear, it is the practice wherever possible to fit a deburring tool to the automatic loading fixture to remove the burrs during the hobbing process. When the gears have been deburred they can be fed through an automatic gear checking instrument.

Technical Report

Readaptation and Re-employment of Workers. Report on a study visit to the U.S.A., Luxemburg: The High Authority of the European Coal and Steel Community. From H.M. Stationery Office, P.O. Box 569, London, S.E.1. Price 8s. 6d.—There can be no progress without changes in the structure of industrial activity. At the same time, the workers have to be protected from the risks and burdens which these changes entail. One of the most important provisions in the Treaty establishing the European Coal and Steel Community is that entitling the workers to readaptation. To ascertain the form in which these problems arise and the ways in which they are dealt with in the economy and labour system of the United States, the High Authority, in 1954, sent to that country a team of nineteen trade unionists from the six Community countries. The team's report, which has now been published by the High Authority of the Community, is available in a number of languages (English, French, German, Italian and Dutch), and is published in a new series entitled "Studies and Documents."

Coal-Fired Closed-Cycle Air Turbine Plant

POWER requirements at the Escher-Wyss works, Ravensburg, have shown a constant increase during the last few years, until they could no longer be met by the existing hydro-electric plant. Because this plant could not be further expanded, it was decided to install additional equipment in the form of a coal-fired thermal plant. The choice lay thus between a steam turbine and a closed-cycle air turbine. In deciding in favour of the turbine, its good part-load characteristics were a decisive factor.

Demand for electric power at Ravensburg varies between 800kW-1800kW during day shifts and 300kW-1200kW during the night. In addition, there is a requirement for space heating during the winter months amounting to approximately 2 Gcal to 2·5 Gcal per hour. These heat requirements do not vary in accordance with the power demand but have to be met also during part-load operation.

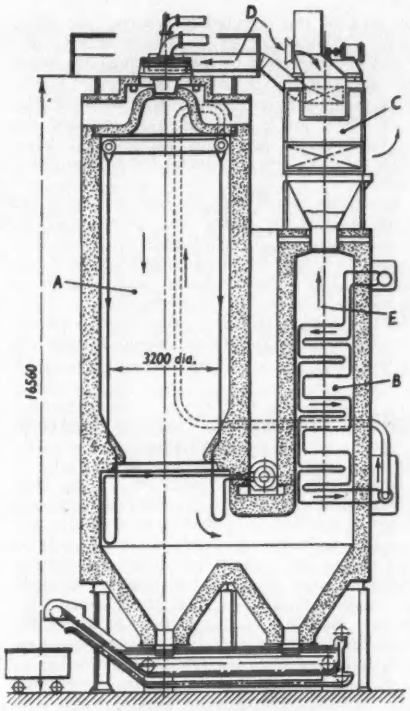
A steam turbine would have had to be built as an extraction condensing plant, developing an overall efficiency of about 22 per cent during the summer when working entirely on condensation, and about 18–19 per cent in winter with extraction. Compared with these values, the closed air cycle turbine will give 26 per cent efficiency at full load irrespective of the amount of heating which has to be done. There is, however, a slight drop in efficiency during those four to six weeks in the year when increased heat extraction has to be covered by raising the temperature. Even at part-load the efficiency of the closed cycle air turbine is very considerable, so that the average overall efficiency throughout the year amounts to about 22 per cent, a value which is much above that which a steam turbine would reach in the same circumstances.

Depending on the return temperature of the water in the heating system, a closed-cycle air turbine plant, it is stated, can supply up to about 1000 k. cal per kWh of energy produced. The lower the return temperature of the heating water, the greater the additional amount of heat available. The hot water is supplied to the heating system at 60 deg. to 100 deg. Cent., if necessary even slightly higher. Any extra heat extracted from the water by decreasing the return temperature is, of course, achieved without an increase in the fuel consumption.

The layout of the Ravensburg plant is as follows: the working medium (pure air) is compressed in the three-stage radial compressor which has an intercooler between stages 1 and 2. The air is then preheated in a recuperative heat exchanger and then enters the air heater, where its temperature is raised to about 660 deg. Cent. The hot air is then expanded in a five-stage axial flow turbine, the exhaust passing over the tubes of the recuperator so as to give up some of its heat to the air from the compressor. Subsequently the exhaust air passes through a precooler which cools it to about 20 deg. Cent. It then returns to the compressor inlet.

Our illustration, Fig. 1, shows a section through the compressor and turbine. The design has only two bearings supporting the shaft on which are mounted the three impellers for the radial compressor and, on the large diameter section, the rotary blading for the five axial flow turbine stages. It will be noted that there is no high-pressure gland. The double-wall design of the turbine, with an internal heat-resisting casing for conducting the 660 deg. Cent. working medium and an external pressure casing of ordinary steel (with intermediate insulation) leads to a considerable saving in austenitic material. The turbine is of small dimensions in relation to the net output of 2MW. The largest diameter of the rotor is only 380mm and the external casing has a diameter of 1200mm. By arranging the compressor and turbine as described, the overall length is substantially kept down. Turbine and compressor revolve at 12,750 r.p.m. and are coupled to the alternator by means of a planetary reduction gearbox.

The coal-fired air heater may be seen in Fig. 2. The burner for pulverised coal, oil, or both together, is arranged centrally at the top of the radiation section on the left. Air in the radiation section travels in the same direction as the combustion gases, after having passed in counter-flow in the convection section on the right. The design is stated to offer the advantage that these tubes which are exposed to the temperature of the flame are readily accessible. Underneath the heater is a wet slag extractor fitted with scraper bands. The coal which is usually supplied in the form of nuts is milled and dried in two "KSG" mills arranged in parallel and blown to the burner by preheated primary air. Two mills of different sizes were used, so as to be able to increase the range of regulation at part-load, and use both mills together during full-load periods. The coal is ignited with oil. Before passing through the induced draught fan and to the chimney, the flow gases from the convection section give up heat to the combustion air in a Ljungström air heater, and pass through a dust extractor.



A—Combustion chamber (radiation section).
B—Combustion chamber (convection section).
C—Combustion air preheater.
D—Combustion air.
E—Flue gases.

Fig. 2—Pulverised coal fired air heater. The burner is above the combustion chamber. A wet slag extractor is arranged underneath the air heater

The air heater was designed very conservatively and it is now considered that higher loads on the combustion chamber are possible. The heater for a 6MW plant, for instance, would need to be only slightly larger than the present one.

Another important component is the recuperator or heat exchanger, part of which is shown in Fig. 3. Double-ribbed tubes were adopted for the first time and were specially developed for this application. Their use is made possible by the fact that the circuit air is pure and does not cause any deposits.

Precoolers and intercoolers employ standard ribbed copper tubes through which the water circulates while the gas is on the outside.

Pipes for the hot working medium are constructed, like the turbine, with double walls, having a thin perforated inner tube of austenitic material which is insulated from the outside pipe and serves only to guide the flow, while the outer pipe takes the pressure. Because the temperature of the outer pipe is much reduced by this design, fewer expansion joints are required.

Losses of air, which amount to about 0·1

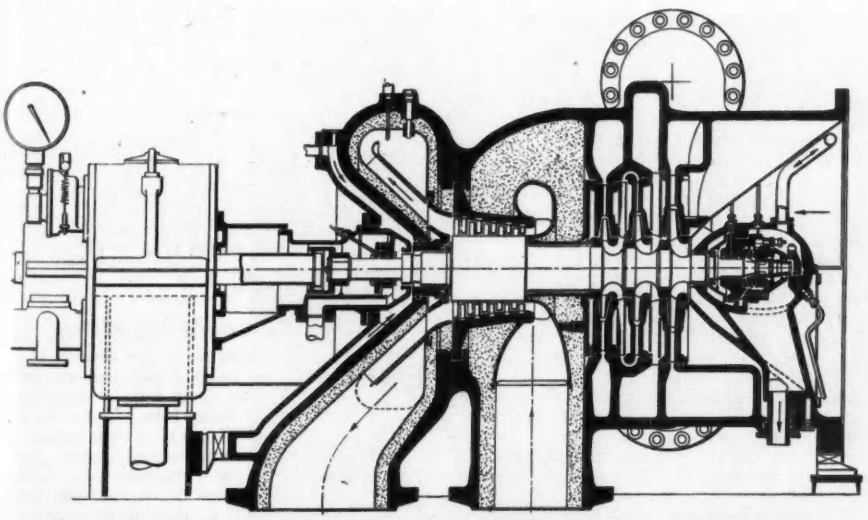


Fig. 1—Section through compressor (3 radial stages) and turbine (5 axial stages). The shaft is supported in two bearings only. The turbine casing has an inner austenitic lining, with insulation filling the intermediate space

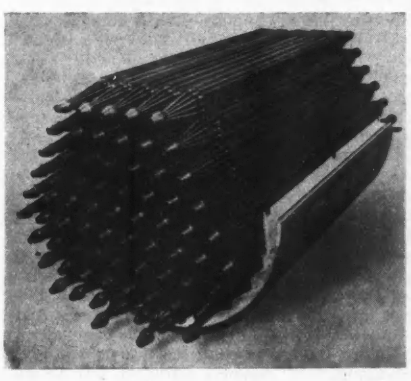


Fig. 3—Part of recuperative heat exchanger with double ribbed tubes. The design is only possible with a closed cycle which excludes deposits. Active tube length is only 2·5m

per cent of the circulating volume, are made up by a compressor set, consisting of a GHH-Lysholm compressor in the intermediate cooler and a Linde reciprocating compressor. The compressors supply receivers at 40 atmospheres, from which air is also taken to increase the system pressure and thus increase the load, while the pressure is reduced for a diminished load.

The plant, which was put into service at the beginning of the year, was constructed by Escher Wyss, Ltd., Zurich, Escher Wyss G.m.b.H. Ravensburg, and Gutehoffnungshütte Sterkrade A.G. (GHH). The air heater was designed in co-operation with the Kohlescheidungs-Gesellschaft, Stuttgart (KSG); the same company also supplied the coal pulverising equipment and the burners.

British Engineers' Visit to German Steel Works

During the period November 27 to December 1, a team of twelve British engineers visited a number of German steel works and factories, with the principal object of studying the German approach to lubrication problems in steel works equipment, and to interchange views on common problems. The works which were visited include Mannesmann Röhrenwerke (Düsseldorf-Rath) (lubrication of rotary furnaces, tube mills and a small continuous tube mill); Capito and Klein (Benrath) (1100mm hot and cold strip mills); De Limon Fluhme and Co. (Düsseldorf) (manufacture and testing of high-pressure lubrication equipment); Klöckner Hüttenwerke (Haspe) (new continuous bar and rod mill); and Oberhausen Hüttenwerke (Oberhausen) (new continuous bar mill, 44in cogging mill, continuous billet mill). The visit ended with a joint meeting with engineers from the Verband Deutscher Eisenhüttenleute.

The general attitude of German steel works engineers towards lubrication appears to be that lubrication should be as reliable and as simple as possible. In regard to grease lubrication equipment, direct line systems were preferred in all places where lubrication really mattered. On a number of occasions it was observed that direct feeding lubricators, centrally fed from a master unit, were situated in niches of passages below the mill, i.e. twelve to twenty-four lines rose almost vertically to the stands. In a number of cases, these lubricators were motorised, the motor being time-clock controlled. In other cases, the motors were electrically connected to the mill motors.

This method of using direct feeding lubricators with no distribution elements or manifolds, no springs and no valves, and charging them from a central lubrication point appears to have the advantages of automatic centralised lubrication by line systems, without incorporating their disadvantages, e.g. eliminating the use of manifolds or distribution elements, which in steel works conditions are liable to damage or to failure.

Single-Line Systems.—Single-line systems seemed to be preferred where conditions did not require continuous application of lubricant, and the team found a considerable number of such systems being utilised. Single-line lubrication, usually hand operated, was found on rotary furnaces, charging cranes for rotary furnaces, continuous tube mills of the smaller sizes, cold strip mills, and other plant.

The single-line systems are stated to be inexpensive, both in respect of equipment and installation. They are designed to have one centralised pumping unit feeding through any arrangement of lines to a number of distribution elements, each one of which is connected with its point of application. These elements are designed in such a way as to lock themselves when they have given up their charge of lubricant, so that within the capacity of the system, the pressure resistance on the bearing has no influence on the amount of metered lubricant fed to the bearing. Even on rotary furnaces and rotary furnace charging cranes, single-line systems had been operating for three and a half years without a single bearing having to be changed.

Closed Fabric Bearings.—Oil and water-lubricated closed fabric bearings were seen on both the continuous bar and rod mill at Klöckner Hüttenwerke, Haspe, and the new bar mill at Oberhausen Hüttenwerke, Oberhausen. In each case the bearing is mechanically oil lubricated through one set of inlet holes and through another set of inlet channels water is injected into the bearing.

The ratio of oil to water is approximately 1 in 1000. The oil is a marine oil which has a slight tendency to emulsify. The team was told that the straight oil would not form an oil film on the fabric bearings and a soluble oil would dissolve in the water and run off immediately. The two oils that were found satisfactory were "Voco" marine oil (Mobil Oil) or "Nautilus" oil (Shell).

Initial troubles on these bearings were due to sticking of the seals. In the beginning, sealing rings were made of the same fabric and tended to swell: they would then stick and the cooling water and scale would enter into the bearing and damage it. Practice had shown that if the sealing ring was made of a composite material—the moving part of phosphor bronze, the remainder of fabric—this difficulty could be overcome.

When this system was introduced at Oberhausen great anxiety was expressed that the already scarce water supply might be contaminated, and in particular the electrical engineers were afraid of their equipment being damaged; but two and a half years' experience had shown that this was not occurring.

Oberhausen had only one water system and all the water was passed through settling tanks. The amount of oil used by a 350mm diameter by 400mm long bearing was 50 grammes per hour. It was so small that only the slightest layer of oil was found on the settling tanks, from where it was removed by skimming. No trouble had been experienced with contamination. Any changing of the segmented closed fabric bearing could be effected very easily; unlike white metal bearings, no pouring or machining was necessary—one merely took one segment out and put another segment in.

The team was told that German practice in regard to fabric bearings was that for speeds higher than 4m per second fabric bearings were not recommended, instead anti-friction bearings are used. For speeds of 1m up to 1·5m per second, water lubrication in itself was sufficient.

For lower speeds, however, oil or grease had to be used in addition to the water. The choice depended entirely on the design of the bearing. In the case of open bearings, grease was used; in the case of the closed fabric bearing, oil was used, as the grease would block the water outlet channels. At all the closed fabric bearing installations seen, the oil was introduced by means of a direct feeding lubricator, centrally fed from a master pump. The amount of oil fed by various works seemed to vary greatly and it would appear that the minimum amount necessary had not yet been established.

Roller Tables.—One of the most interesting matters observed was the abandonment of the oil circulation system on the roller tables of the hot strip mill at the works of Messrs. Capito and Klein, and its replacement by a two-line hydraulic grease system. When this mill was built two years ago, it was considered that these bearings should be oil lubricated and attached to the general circulation system. During the first year of operation, it was found that particularly as high descaling pressures (2000 lb per square inch) were used, a considerable amount of water trouble resulted, and after many attempts to put matters right it was decided to attach the roller table to the grease system and not to the oil circulation system. The question was raised later during the joint meeting and the German lubrication engineers agreed that where there was water, and in certain other cases, grease systems should be used.

One case was reported where, on the working table of a cogging mill, the pinion design had been altered so as to utilise spur gears instead of bevel gears, and to separate the driving part from the actual roller table. This facilitated grease lubrication of the roller table and oil lubrication of the gears in their box.

Slipper and Palm End Lubrication.—Mechanical lubrication of slippers on palm ends seems to be common practice in Germany now, since lubrication by this means, not only on the palm ends of the mill side, but also on the palm ends of the motor side, is much cheaper than the oil flooding system practised in this country.

Specification of Lubricants.—Strong representations were made by the Verband Deutscher Eisenhüttenleute for better specification of both lubricants and lubricant requirements by oil companies and designers of equipment respectively. One of the most important specifications for circulating oil concerned water separation properties. The only emulsification tests available were established for turbine oils and oils working under steam conditions. However, rolling mill conditions were not the same as those on turbines. An oil shaker, or some similar apparatus, should be developed and standardised, because the water separation rate affected the size of tank required for any circulation system. Another test urgently required was one establishing the percentage of additives left in a lubricant after a period of use. The trend in German steel works was to find out more and more about the lubricants used and not to rely on oil companies as is customary in Britain.

The visit was arranged by Dr. Alfred Schmemann (De Limon Fluhme, Düsseldorf) and Mr. H. Peter Jost (Centralube, Ltd., London). A return visit by German steel works lubrication engineers of the Verband Deutscher Eisenhüttenleute is tentatively planned for April, 1957.

German Chemical Industry

In the first nine months of 1956, German chemical exports rose by 12·5 per cent to approximately 2770 million DM. This compares with 16 and 32 per cent for the corresponding periods in 1955 and 1954. The reduction is attributed to the preference of underdeveloped countries for capital goods rather than consumer goods, to which category most of the chemical production belongs. Foremost among exports are heavy chemicals (662 million DM., representing 24 per cent of the total exports), second place being taken since the end of 1955 by plastics, including plastic sheet and foils (250 million DM.). Aniline dyes receded to fifth place with 208 million DM., a reduction of 19,000,000 DM. This is thought to be due to international competition and the increasing foreign manufacturing capacity. Pharmaceuticals increased to 247 million DM., while nitrogen fertilisers decreased to 190 million DM.

West German production of plastic foils (notably soft PVC) increased again by 8 per cent, making it likely that a turnover of 140 million DM will be reached this year. Plastic floor coverings and tiles are expected to exceed 20,000,000 DM this year. Exports of plastic foils and artificial leather remained on last year's level (32 and 10·5 per cent respectively of the total turnover, compared with 35 and 11·5 per cent in 1955). In the case of PVC floor coverings, the proportion of exports increased from 9 per cent of the total production in 1955, to 12 per cent this year.

Chemical imports increased by 10 per cent, to reach 973 million DM., almost the same as the increase in the export figures. Of this total, raw materials accounted for 189 million DM. (increase 5 per cent), while semi-manufactures and finished products amounted to 784 million DM. (increase 12 per cent). Synthetic fibres (102 million DM.) and plastics (63,000,000 DM.) showed the largest percentage increases (25 and 35 per cent respectively). Pharmaceuticals (57·4 million DM.) increased by 18 per cent. Heavy chemicals still top the list with 147 million DM., although the percentage increase was small, while imports of dyestuffs decreased.

North German Experimental Reactor

The experimental reactor of the four North German Länder is to be sited near Tesperhude/Geesthacht, in the Geesthang hills, about 50m above the level of the River Elbe. The reactor is to be built into the hillside for safety reasons, and will be of the "swimming-pool" type. An important aspect of the work which is to be carried out will be the testing of materials for radiation shields, with a view to developing lightweight shielding for marine propulsion. The reactor is to be constructed by the Deutsche Babcock and Wilcox A.G.

National Metal Congress and Exposition

BY OUR AMERICAN EDITOR

No. III—(*Concluded from page* 903, *December* 21)

Spray Coating

THE initial demonstration of the "Vanco" metallising gun took place at the booth of the Vandersee Corporation, of Union, New Jersey. One of the outstanding aspects of this new design is the use of a governor-controlled air turbine drive. Dynamically balanced, the air turbine provides positive, power control uniformly feeding metal wire without fluctuation. The turbine is automatically governed by the propulsion fluid supplied to the primary and secondary turbine, arranged so that their opposing forces are in direct proportion to the change of volume or pressure of the fluid supply. The gas mixing chamber wire nozzle of the gun incorporates a new development of mixing the gas and oxygen at the point closest to combustion, thus completely eliminating back-fire. No adjustments are required on the air cap, and each wire nozzle is specifically designed to provide the exact proportion of gas and oxygen used. To provide efficient heat distribution, the number of orifices in the nozzles varies according to the diameter of the wire used.

The new gun has all its six anti-friction bearings mounted in a one-piece gear case, ensuring positive alignment and lubrication of all moving parts. To prolong the life of the moving parts, a light oil is sealed in the gear case with synthetic rubber seals. Constant wire feed into the gun is accomplished by a compound turbine containing a rotor and stator responsive to opposing propulsion fluids. One propulsion fluid jet remains in a fixed position in the primary turbine to develop the power for rotation. The other fluid jet angle is adjustable, causing the propulsion fluid to impinge upon the secondary rotor vanes opposing rotation, thus resulting in automatic compensation for subsequent air fluctuation. A slight up or down movement of the turbine control lever instantaneously increases or decreases the wire feed. The constant abrasive action of the wire passing through the nozzle insert causes wear. The "Vanco" nozzle has a replaceable hardened steel wire sleeve insert that prolongs the life of a nozzle indefinitely. The inserts are easily installed and are available, with a renewing tool, for all wire diameters.

Another interesting new gun development in the field of spray coating was exhibited by the Metallizing Engineering Company, of Westbury, New York. The so-called "Type P Thermospray" gun (Fig. 8) incorporates a new principle which permits thermal spraying of a number of materials without the use of compressed air. The thermal efficiency achieved in the design of the gun permits the use of comparatively high melting-point materials, such as the boron-silicon self-fluxing alloys used for hard facing and corrosion resistance; stainless steels, chromium-nickel alloys, bronze and ceramics, such as alumina and zirconia. The gun is claimed to apply these materials many times faster than any previously known powder gun, and deposit efficiencies range between 95 and 99 per cent.

The powders, which have been especially developed for use with the gun, are held in a reservoir atop the gun or in a separate hopper from which they are fed to the gun through a hose. The powders are gravity fed through an abrasion-resistant connector into the gun proper, where they are picked up by the gas flow and fed to the gun nozzle. Since the gun requires no compressed air there are only two lightweight hoses attached to the rear of the gun. Oxygen and either acetylene or hydrogen are used, depending on the work and the powder to be sprayed. The design of the gun nozzle is such that the material being sprayed is heated efficiently and melted thoroughly. A siphon-jet arrangement at the gun nozzle not only contributes to the high thermal efficiency of the gun but helps to propel the particles to the surface being sprayed. A small, electrically-operated vibrator, which is attached to the gun below the nozzle, is supplied for use when spraying the ceramics to ensure a smooth flow of the lighter-weight materials.

The Refractories Division of the Norton Company, of Worcester, Massachusetts, introduced its "Rokide" spray coatings at the Metal Show. These coatings consist of hard, adherent crystalline refractory oxides which protect the underlying material from high temperatures and from abrasion. The coatings are both thermally insulating and electrically insulating. They can be applied to a variety of materials, and are particularly adaptable to metals. Because of their hardness, the coatings reduce the erosion of metal parts. The coatings are inert to attack by most chemical agents and stable in combustion atmospheres, so that they will reduce the corrosion of metal parts. When exposed to heat, their high melting points and low thermal conductivities reduce the metal temperature or permit higher operating temperatures. The coatings are showing considerable promise for rocket, jet engine and guided missile components such as nozzles, motor tube linings, vanes, motor components, tail pipe linings, inner combustion chamber linings, cross fire tube linings, flap nozzles, housings and shroud ring insulations.

It should be borne in mind that there are some limitations to the coatings. Ceramic materials are non-ductile at room temperatures. Their compressive strengths are about ten times greater than their tensile strengths. Therefore, when the coating is stressed, it will withstand much more stress in compression without failure than in tension. This is borne out in thermal cycling tests of coatings on concave and convex surfaces. Coatings on concave surfaces, such as the inside diameter of a tube, will withstand many more cycles of heating and cooling than will a coating on the outside of a tube or cylinder. Stresses are set up by the expansion and contraction of the metal and the coating as the part is heated and cooled. At times another limitation of the coatings is their slight permeability. In some cases, with time as a factor, corrosive agents will permeate the coatings and attack the metal, although such attack will be a great deal slower than in the case of uncoated metal.

The "Rokide" spray coatings are produced by heating the end of a solid rod to fusion and projecting the molten particles at a high velocity against a surface where they adhere and solidify. Although coatings of alumina, zircon and zirconia are now commercially available, a number of other materials have been successfully processed on an experimental basis. Almost any material which meets the following requirements can be applied as a coating; it must melt rather than sublime, may or may not produce a coating, and must form droplets rather than threads. Obviously, there are many materials which would meet these requirements. The process is not a limited one, since it is possible to prepare coatings from refractory oxides and oxide compounds. For example, some of the oxide coatings which have been prepared are: aluminium oxide, zirconium oxide, titanium oxide, magnesium aluminate, iron oxide, zirconium silicate, and chromium oxide. Porcelains and cermets are other examples of mixtures which have been made as coatings. The coating process is covered by U.S. Patent No. 2,707,691 and licences can be obtained from the Norton Company.

A demonstration of flame plating, shown in the illustration (Fig. 9), was one of the most interesting displays at the booth of the Linde Air Products Company. This method of metal surfacing is a detonation process and is performed in an acoustically treated chamber, using a specially constructed gun. The gun consists basically of a barrel, a mechanism for loading powder, acetylene and oxygen into the firing chamber, and an igniting system. Measured amounts of powdered coating are supplied to the gun from a dispenser in a carrying stream of gas. The powder remains suspended in the explosive gas mixture until it is ignited by an ordinary spark plug. The barrel of the gun is designed to concentrate the heat and pressure waves produced in the explosion. When the temperature inside the gun reaches 6000 deg. Fah. the heat waves begin to move faster than the pressure waves, resulting in detonation rather than simple combustion.

The heat waves move through the gas and powder mixture about ten times faster than sonic velocity, completely burning the gases and building up a high pressure within the barrel. When the detonation wave leaves the barrel it is transformed into a shock wave, which dissipates into the surrounding air, carrying with it the particles of molten coating materials. The kinetic energy of these high-velocity particles is high enough to embed them in the workpiece. Repeated detonations, about four per second, build up a homogeneous coating. Although the temperature inside the gun reaches 6000 deg. Fah., the part being plated never exceeds 400 deg. Fah. because of the rapid dissipation of the heat waves as they emerge from the gun barrel. Even when high-melting materials are being deposited the workpiece remains relatively cool. This fact, and the small mass of coating applied during a single detonation, make the process suitable for thin and easily deformed structures.

Until recently, most flame-plating applications have used tungsten carbide coatings, but aluminium oxide can now be used. This oxide coating has excellent resistance to chemical attack and high temperatures, combined with hardness, abrasion resistance and low porosity. It can be used in such applications as seals operating under heat and in corrosive media, thrust bearings, pump plungers, engine parts, and heat-resistant insulated surfaces for electronic components.

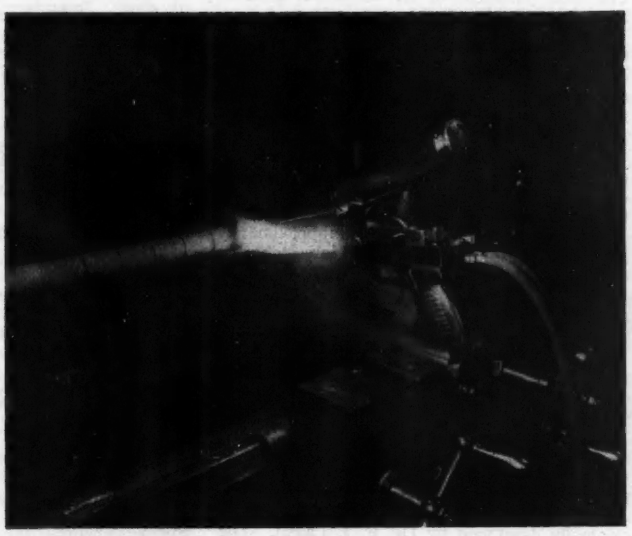


Fig. 8—Metco "Thermospray" metal powder spray gun depositing a self-fluxing alloy of nickel, chromium and boron

Fig. 9—Demonstration of Linde "Flame-Plating" tungsten carbide metal surfacing process

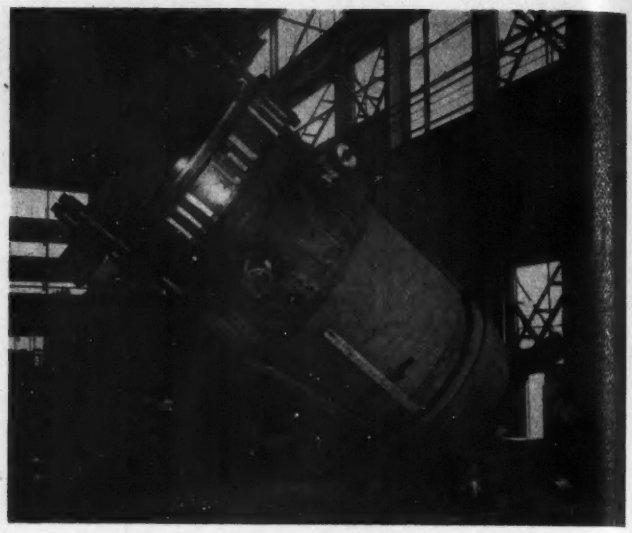


Fig. 10—235-ton reactor pressure vessel fabricated by Combustion Engineering for the Shippingport atomic power station

Pressure Vessels

Details relating to one of the outstanding recent fabrication projects involving pressure vessels were released by Combustion Engineering, Incorporated, of New York. The reactor vessel, which is shown in the illustration Fig. 10, was constructed at the Chattanooga works of the firm in Tennessee and is now being installed at the first American full-scale commercial nuclear power station to be operated by the Duquesne Light Company at Shippingport, Pennsylvania. The reactor vessel is designed to withstand a 2500 lb per square inch gauge internal pressure at 600 deg. Fah. At the rated load 26,000,000 lb of primary coolant water will enter the vessel each hour through four inlet nozzles and pass through the core, where the temperature will be raised from 507 deg. Fah. to 542 deg. Fah. The dry weight of the vessel is 235 tons, of which the shell portion weighs 150 tons and the removable top head 85 tons. In addition, the vessel will contain thermal shields, a core assembly and other equipment having a total weight of an additional 100 tons. The internal diameter is 9ft 1in and the length from the inside of the lower head to the inside of the top head is 31ft 3in.

The top head is fastened to the shell section by means of forty-two 6in diameter studs, each 80½in long. Each stud with its accompanying nuts weighs 700 lb. To secure the head to the vessel shell these studs are elongated by heat supplied from electric heaters extending into the centre of the studs so that the nuts can be turned through a predetermined angle to induce the required stud tension when the studs cool to ambient temperature. The stud tension required to maintain contact of the mating surfaces of the head and shell under design conditions is 40,000 lb per square inch. The removability of the head is a design requirement to facilitate the servicing of the interior of the vessel.

Since the hot primary coolant water circulated through the reactor vessel is corrosive, the internal portions of the vessel are clad with a ¼in minimum thickness of a corrosion-resistant stainless steel. The hemispherical bottom head and shell courses were fabricated from manganese-molybdenum clad plate having 6in. and 8¾in minimum thicknesses respectively. These integrally clad plates were fabricated by the Lukens Steel Company. The massive head hemispherical portions of the removable head could not be procured with the stainless steel integrally clad. In order to clad these thicker sections a special device for cladding the base metal by weld deposit was developed at the Chattanooga shops of the company.

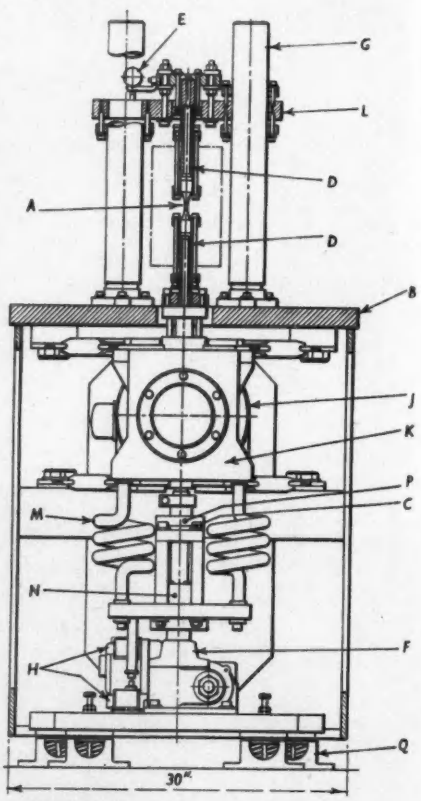
The base material of the vessel is manganese-molybdenum steel, meeting the requirements of the A.S.M.E. Material Specification SA-302, Grade B, which calls for a minimum tensile strength of 80,000 lb per square inch. The specified composition is manganese 1·10 to 1·50 per cent, molybdenum 0·40 to 0·60 per cent, and carbon 0·27 per cent. The stainless cladding is A.I.S.I. Type 304-L, 18 per cent chromium, 8 per cent nickel steel, with a maximum specified carbon of 0·03 per cent. The bond between the cladding and the base metal must be sufficient to meet the shear test requirements under A.S.M.E. Specification SA-264, and the continuity of bond was ensured by ultrasonic reflectoscope inspection of 100 per cent of the plate surfaces.

Some idea of the problems regarding manufacturing of the reactor vessel can be gained by realising that the parts making up the vessel were the biggest and heaviest of their kind ever made by the firm. The procurement of plate material presented one of the more difficult problems. This involved getting very thick and heavy clad plates with an integral bond between the clad and backing plate. The flanges for the vessel and heads presented difficult alloy-steel forging problems, which were finally solved by the Bethlehem Steel Company. After forming the parts, the mating edges were machined to provide welding grooves. All of the welding operations were required to be performed while the parts were kept hot, thus increasing the difficulties of fabrication. Welding of the thicknesses involved up to 10in required very close control of the welding technique. Radiographing of the welds joining the various parts was performed on a 15 MeV betatron. The heat treatment of all welds was done in large heat-treating furnaces at elevated temperatures to relieve the stresses in the material. On some parts the accumulated heat-treating time amounted to about sixty days. All clad surfaces were inspected with a dye penetrant fluid to ensure the absence of any minute flaws. All the backing plate surfaces were inspected with a magnetic particle test to ensure freedom of defects. The machining was accomplished on large and special equipment designed primarily for this kind of vessel. The final machining operation involved a period of approximately sixty days on one of the world's largest boring mills. The machining operation was performed using optical methods to align various matching machined surfaces.

Mechanical Testing Equipment

The Ivy Company, of Norwalk, Connecticut, exhibited its Model "BJL-1" dynamic creep testing machine which has been developed to fill the demand for a simple, inexpensive and easily maintained fatigue and dynamic creep testing machine for use either at room or elevated temperatures. To fulfill this requirement, the company designed this unit based on a machine originally developed by Dr. B. J. Lazan. The Lazan machine was selected because of its proven performance during several years of continuing use. It is of particular interest to note that the machine has an adjustable bumper incorporating an amplitude limit switch. In most tests the proper adjustment of the bumper will stop the machine immediately before the specimen is completely fractured, making it possible to conduct metallurgical examinations of the fatigue-creep fracture.

The machine is shown in the sectional



A—Test specimen.
B—Machine cabinet.
C—Flexure pivots.
D—Specimen grips.
E—Dial indicators for specimen alignment.
F—Screw jack with geared motor drive.
G—Columns.
H—Limit switches.
J—Motor, oscillator drive.
K—Oscillator housing, containing adjustable eccentric mass.
L—Upper platen.
M—Static force springs.
N—Static force sensing element.
P—Mechanical bumper.
Q—Vibration isolators.

Fig. 11—Section through Ivy model "BJL-1" dynamic creep testing machine

drawing in the illustration, Fig. 11. The alternating force is produced by an adjustable eccentric mass which is supported on bearings in an oscillator housing. The eccentric is rotated at 3600 r.p.m. by the synchronous motor through the flexible couplings. The oscillator housing is guided by the flexure pivots which allow the oscillator only vertical motion. The flexures absorb the horizontal component of the centrifugal force produced by the eccentric. The static tension force is applied through the springs held at one end to the oscillator housing and at the other to the screw jack which is driven by the gear motor. The sensing element is used to measure the static extension of the springs. The sensing element also energises electronic controls which start and stop the gear motor as needed to maintain the desired tension during the test.

The specimen is held by the grips which are made of high-temperature resistant alloys. The lower grip is fastened to the top of the oscillator, while the upper grip is held to the upper stationary platen which is supported by three columns. These columns are threaded to enable a vertical adjustment of the plate in order to accommodate specimens of various lengths. Dial indicators are provided for indicating the angular displacement of the upper grip and thus preventing such displacement during the clamping of the specimen grip assembly prior to a test. This enables the proper clamping of the specimen in position without introducing undesirable clamping stresses that cannot be accounted for and thus cause erroneous results. The machine is housed in a heavy cabinet which is seismically supported on the floor by the vibration isolators. This prevents vibrations from being transmitted to the floor, and makes it possible to place this machine on any floor that can carry its weight. No special foundations are, therefore, needed.

The vibrating and static and dynamic force applying the mechanisms of the machine are protected by a mechanical bumper which prevents excessive deflection of the springs. Three limit switches stop the motors when the motion of the oscillator or the travel of the jack exceed allowable limits. One or more of these limit switches are tripped at the end of a test upon fracture or excessive creeping of the test specimen. A revolution counter registers the number of cycles of stress in the specimen. It is driven at 3·6 r.p.m. by a timing motor which starts and stops at the same time as the motor. A special control cabinet contains the magnetic motor starters, push-button controls and indicating lights, as well as the cycle counter and the electronic control box for the static force. An auto-transformer is also supplied for the gradual starting of the motor, which is necessary to prevent overloading the test specimen at the time the test is started. A safety feature incorporated in this circuit makes the full-speed starting of the motor impossible.

The furnace of the machine is electrically heated and is supported by a bracket so as to surround the test specimen. Thermocouples mounted on the surface of the specimen are used in conjunction with the temperature controller recorder, which accurately maintains and records the temperature of the test specimen. The furnace and controls are electrically disconnected upon failure of the test specimen.

The creep recorder furnishes a record of the elongation-time curve of the specimen undergoing test. Creep is measured directly between the two ends of the specimen by means of the dynamic stress extensometer recently developed by Dr. B. J. Lazan. A differential transformer pick-up is incorporated in the extensometer. The electrical signal from the differential transformer is a measure of creep and is recorded on a strip chart recorder. The dynamic stress extensometer gives unusually accurate results because it is directly attached to the specimen. Thus, unlike most other available methods, errors resulting from the indirect measurement of creep in a dynamic testing machine are eliminated. When both the temperature and the creep of the specimen must be recorded, these two variables can, if desired, be recorded on the same chart by using a two-pen recording instrument.

Several interesting high-speed rotating beam testing machines were shown at the stand of Krouse Testing Machines, Incorporated, of Columbus, Ohio. The firm's three sizes of machines are of the same general construction and follow the same principle of operation. The 60,000in-lb machine is capable of testing 3in to 4in diameter specimens at zero to 60,000 in-lb bending moment. The 10,000in-lb machine is capable of testing specimens from 1¼in to 2¼in diameter at zero to 10,000in-lb bending moment. The 1500in-lb machine is capable of testing ⅜in to 1¼in diameter specimens at zero to 1500in-lb bending moment. In each machine the entire operating assembly is mounted on a rigid beam supported on vibration isolators to eliminate noise. A heavy-duty motor, inside the machine cabinet, powers the driving spindle by means of a belt drive over a variable pitch pulley. The specimen is mounted between the driving spindle and the bending arm. A deadweight load is applied to the free end of the bending arm through a weight beam linked to it by a rod and yoke. The weight beam is graduated in 1000in-lb steps with the weight micrometer dial graduated in 10in-lb steps. A precision cut-off switch, mounted directly under the weight beam, can be adjusted to stop the machine when the slightest increase of deflection of the specimen occurs. A reset counter which is mounted at the top of the machine records each 100 cycles up to 100 million cycles.

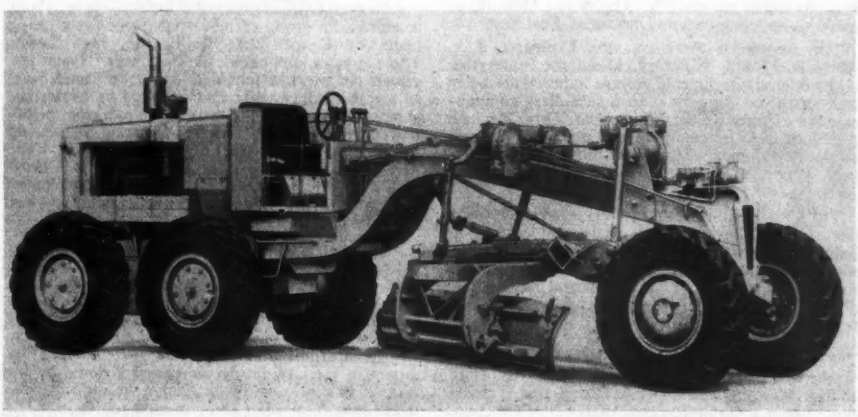
Gregory Award

During the National Metal Congress, Mr. George E. Gregory, President of Gregory Industries, Incorporated, of Lorain, Ohio, manufacturers of the Nelson stud welding equipment, announced the first annual Gregory Award. A cash award of 1500 dollars—or 2000 dollars in scholarships for any individual or college of the winner's choice—will be given for the year's most outstanding contribution in the field of semi-automatic electric arc stud welding. A complete stud welding unit will also be presented to the engineering school or college whose students and faculty shall have submitted the most outstanding group of entries in this competition. Additional equipment awards to educational institutions will be made on the recommendation of the judges if warranted by the calibre and the number of entries. The principal award will be made to the person responsible for the development of stud welding application or studs which shall be judged most significant on the basis of: (1) reducing costs for industry; or (2) improving the appearance, serviceability and life of a product or structure; or (3) performing a function not possible by any other method. Residents of the United States, Canada, and all other countries where the Nelson stud welding process is presently in use, are eligible for the award. Individuals in any way associated with the manufacture, sale or distribution of stud welding equipment are not eligible for this competition. Entries will be judged by a committee of four engineers under the chairmanship of Dr. Donald S. Clark, President of the American Society for Metals. Entries must be postmarked before midnight, June 30, 1957, and should be mailed to Dr. Donald S. Clark, Chairman, Gregory Award Committee, 7301, Euclid Avenue, Cleveland, 3, Ohio.

Motor Grader Equipped With Torque Converter

The accompanying illustration shows the new "Power-Flow 660" motor grader which has been added to the line of earth-moving plant made by the Le Tourneau-Westinghouse Company, of Peoria, Illinois. The grader is equipped with a 190 h.p. diesel engine, a single-stage torque converter and a four-range constant-mesh transmission. An interesting design aspect contributing to the speed and ease of handling of the new unit is a mechanism which allows the operator to make changes in travel from forward to reverse, and vice versa, without hand shifting. It is accomplished with a rocker pedal situated on the cab floor at a point where the clutch pedal would be in a standard transmission machine. To set the grader in motion forward, in any previously selected range, the operator has only to press the rocker pedal with his toe. To shift to reverse he merely rocks his foot on the pedal applying pressure with his heel, and change of direction is immediate. At all times in this shifting operation the operator's hands are free to manipulate the steering, blade and other controls. According to the designers, this simple high-speed system will prove a distinct advantage in shuttle work on heavy construction projects, shoulder sloping, and bucking drifts in snow ploughing where quick machine co-ordination is important.

Another item to help the operator and let him give full attention to the machine's work functions is a tail-shaft governor which automatically adjusts engine speed. Using this governor, the operator can set the speed at which he chooses to work with either the hand throttle or the foot accelerator, and eliminate any further manual throttle manipulation. The governor automatically measures requirements of varying resistance, load and grade and makes the necessary adjustment in engine speed to compensate and maintain a constant travel rate. The flexibility of power which the torque converter provides makes the machine ideally suited for such grader jobs as bank sloping, ditching, heavy grading, and other work where there are alternate light and heavy loads on the blade. In addition, the converter helps to contribute substantially to the mobility of the unit by making it more agile in traffic. With the selector set in the high range the grader can sprint from a standing stop to full speed without the necessity of manual gear shifting. The construction of the torque converter and constant-mesh transmission provides four forward speed ranges from a creeping 0·23 m.p.h. to 27·4 m.p.h. The instant reverse provides an equal number of ranges from 0·22 m.p.h. up to 24·4 m.p.h.



Le Tourneau-Westinghouse "Power-Flow 660" motor grader equipped with torque converter

Personal and Business

Appointments

MR. ROY S. FENTON has been appointed home sales manager of Chaseside Engineering Company, Ltd.

MR. GEORGE DOW has been appointed assistant commercial manager, London Midland Region of British Railways.

PROFESSOR JACK ALLEN, M.I.C.E., Professor of Engineering at Aberdeen University, has become a member of the British Transport Commission's research advisory council.

SIR HENRY WILSON SMITH has been appointed chairman of Powell Duffryn, Ltd. He succeeds Sir Herbert Merrett, who has resigned from the boards of Powell Duffryn, Ltd., and its associated companies.

THE NATIONAL COAL BOARD has announced the resignation of Mr. W. Charlton Edwards from the position of finance director of the West Midlands Divisional Board. Mr. W. M. Crooks has been appointed to succeed him.

BRISTOL AERO-ENGINES, Ltd., Bristol, announces the appointment of Group Captain S. O. Tudor as chief liaison officer, and of Air Commodore B. A. Casey as deputy chief liaison officer. Mr. L. C. R. Phillips has joined the staff of the engineering liaison department.

THE BRITISH POWER PRESS MANUFACTURERS' ASSOCIATION states that Mr. H. D. Challen, A.M.I. Mech.E., a director of Taylor and Challen, Ltd., has been re-elected chairman. Mr. E. C. Seed, M.I. Mech.E., chief engineer of Cowlishaw, Walker and Co., Ltd., has been elected vice-chairman.

Business Announcements

THE MULLARD ORGANISATION has moved to Mullard House, Torrington Place, London, W.C.1 (telephone, Langham 6633).

THE HEAD WRIGHTSON EXPORT COMPANY, Ltd., Thornaby-on-Tees, has opened an office at 21, Netaji Subhas Road, Calcutta, 1.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that its depot at Camden Street, Derby, now has an additional telephone number, Derby 44282.

BRITISH OXYGEN GASES, Ltd., has completed a programme of reconstruction and extensions at its premises at Tunnel Avenue, Greenwich, London, S.E.10.

MCKECHNIE BROTHERS, Ltd., Birmingham, states that John Hood and Co., Ltd., 55, Cheapside Street, Glasgow, C.3, is now the sole selling agent in Scotland for its metals.

AIR CONTROL INSTALLATIONS, Ltd., Ruislip, states that its Birmingham office has been moved to Wolverley House, Digbeth, Birmingham, 5 (telephone, Midland 5148).

THE INCANDESCENT HEAT COMPANY, Ltd., Smethwick, Birmingham, states that Mr. M. V. Jackson, technical representative, has moved to Hadfield House, Ecclesall Road South, Sheffield, 11 (telephone, Sheffield 65927).

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH states that Dr. Albert Parker is retiring on December 31 from his position as Director of Fuel Research. He has completed twenty-eight years in the service of the D.S.I.R. and has been Director of Fuel Research since 1943. Dr. A. C. Monkhouse has been appointed acting Director of Fuel Research.

THE LIGHTFOOT REFRIGERATION COMPANY, Ltd., Abbeydale Road, Wembley, Middlesex, states that all its interests in the cold storage industry are being transferred, on January 1, to a subsidiary company entitled Lightfoot Cold Stores, Ltd. Mr. Kenneth Lightfoot is to be chairman and managing director of the new company, and Mr. John A. Howie has been appointed managing director of the parent company.

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY has set up a commercial department within its industrial group, to handle sales of uranium, plutonium, thorium, graphite and other similar materials for the Authority. Within the general policies laid down by the Authority, this department will be responsible for negotiating terms and conditions of sale, including the determination of selling prices. The manager of this department is Mr. W. P. Warren, whose address is U.K. Atomic Energy Authority, Industrial Group Headquarters, Risley, near Warrington, Lancs. Radioisotopes, stable isotopes, and special requirements for small quantities of research materials will continue to be handled by the Research Group of the Atomic Energy Authority.

Contracts

THE HUNSLET ENGINE COMPANY, Ltd., Leeds, has received from The Consett Iron Company an order for eleven more heavy duty steel works locomotives, at a total value of nearly £150,000.

THE GOOLE SHIPBUILDING AND REPAIRING COMPANY, Ltd., has received an order from Mason Trawlers, Ltd., for a trawler of length between perpendiculars 137ft by 28ft beam by 14ft 3in moulded depth. The ship will be propelled by a Mirrlees K.S.S.D.M. diesel engine developing 1000 h.p. at 260 r.p.m. and a Robertson electric trawl winch.

Miscellanea

NATIONAL BOAT SHOW.—The third National Boat Show, sponsored by the *Daily Express*, will open at 11 a.m. on Tuesday, January 1, 1957, in the Empire Hall, Olympia, London. The show will continue until January 12.

DIESEL ENGINE SPEED INCREASE.—Davey, Paxman and Co., Ltd., announces that it has increased the top speed of the R.P.H. four-stroke engines from 1250 r.p.m. to 1500 r.p.m. At the higher maximum speed the output of the four, six, eight, twelve and sixteen cylinder units is, respectively, 160 b.h.p., 274 b.h.p., 366 b.h.p., 562 b.h.p. and 750 b.h.p.

WINFRITH HEATH ATOMIC RESEARCH PROJECT.—The Minister of Housing and Local Government, Mr. Duncan Sandys, has directed Dorset County Council to refer to him for decision the application made by the United Kingdom Atomic Energy Authority for planning permission for the projected research establishment at Winfrith Heath. A local inquiry is to be held early in January.

FILMS.—A new colour film recently completed by Simmonds Aerocessories, Ltd., Treforest, Pontypridd, Glamorgan, entitled "Nothing Rattles the Nyloc," was shown in London last week. Many applications of the self-locking nuts manufactured by the company were shown, and their usefulness in a variety of industries demonstrated. A second film, entitled "Hold Tight," illustrated the adaptability of "Spire" speed nuts. Both films are available in 16mm size.

METAL PROTECTION.—A metal primer for stopping rust and known as "Glopane Universal," has been developed by Corrosion, Ltd., Malvern Road, Southampton. It is claimed that this zinc-based material can be painted on iron and steel in either wet or dry weather or even under water if necessary. It dries hard in about twenty-four hours, leaving a coat of zinc which resists abrasion, renders any existing rust inert, and protects a structure from further rusting. Most kinds of paints, excluding bitumens, can be applied on the primer.

SMALL AIR COMPRESSOR.—An air compressor designed to deliver a small volume of air at pressures up to 50 lb per square inch has been introduced by B.E.N. Patents, Ltd., High Wycombe, Bucks. It is a completely self-contained set consisting of a 2in bore by 1in stroke, single cylinder compressor which is coupled to a ¼ h.p. motor and has a displacement of 1·7 cubic feet per minute. The compressor and its drive are mounted on a 1·25 cubic feet capacity air receiver and the assembly includes a finned expansion chamber, air intake filter, silencer, air pressure gauge, relief valve and a pressure regulating valve.

INDUSTRIAL GREASES.—Particulars have been received of a group of industrial greases now being made by Rocol, Ltd., Swillington, near Leeds. These greases are based on the firm's "Bentone" greases, in which a modified bentonite clay is used as the thickening agent and is stated to render the greases very heat stable, resistant to working, highly repellant to water and enables them to be used up to the point of inflammability of the basic oil. The new greases have been given the trade name "Molytone" and in them there is combined molybdenum disulphide to give improved lubricating and pressure resisting qualities.

PORTSMOUTH'S MAIN DRAINAGE.—A booklet entitled "A History of Portsmouth Drainage, 1856–1956," written by the Portsmouth City Engineer, Mr. W. E. C. Chamberlain, has been published by the city corporation on the occasion of the coming into service of the Cosham mainland pumping station. The main drainage and sanitation system which has grown in the city during the period covered by the history has been a major factor in reducing the death rate from 25·3 per thousand to 10·76. The total cost of the post-war drainage schemes is expected to be about £480,000. The new mainland station has fully automatic machinery.

INSTITUTE OF METALS AWARDS.—The Institute of Metals has announced awards of medals as follows: the Institute of Metals (Platinum) Medal for 1957 to Dr. Maurice Cook, F.I.M., joint managing director, Imperial Chemical Industries, Ltd., Metals Division, in recognition of his outstanding contribution to the science of metallurgy, to the non-ferrous metals industry and to the welfare of the metallurgical profession; the Rosenhain Medal for 1957 to Dr. H. K. Hardy, A.R.S.M., A.I.M., research manager, United Kingdom Atomic Energy Authority, Industrial Group, in recognition of his outstanding contributions to knowledge in the field of physical metallurgy.

NYLON NUTS FOR STAINLESS STEEL FITTINGS.—As a result of its experience with stainless steel fittings for the milk and food industries, the Talbot Stead Tube Company, Ltd., Green Lane, Walsall, considers that the use of stainless steel for the hexagon nut on fittings having a rubber ring or other sealing media is unnecessary. The firm has now developed a nut made from nylon produced as a machine moulding for its stainless steel fittings. Under the manufacturing process the nylon is fully saturated before despatch by the firm to eliminate the drawback of nylon in that it absorbs moisture from a humid atmosphere. The nuts are made in three colours for line identification purposes and in 1in, 1¼in, 2, 2½in and 3in dairy pipe fittings sizes.

SIGNAL INSTALLATION AT FARRINGDON.—The biggest push-button-operated signalling installation installed by London Transport to date has been placed in service on the Underground's Circle Line. This installation is situated at Farringdon and it will enable the complex traffic on the whole of the line as far as Liverpool Street to be worked from one desk equipped with eighty-one illuminated plastic buttons. Four cabins equipped with signal levers were originally necessary. The line is used daily by 850 Circle, Hammersmith, London Midland and Eastern Region passenger trains, and main line goods trains. The operating panel is situated in a rebuilt signal cabin at Farringdon and is linked with sixty-seven signals and fifty-four pairs of points through interlocking equipment in which steel shafts operated by compressed air cylinders carry out movements formerly made manually by signalmen in the various cabins.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—At a meeting of the Institution of Engineers and Shipbuilders in Scotland, held in Glasgow, on Tuesday, December 18, Mr. J. Turnbull presented a paper entitled "Hull Structures." The paper notes that the outstanding recent change in ship construction has been the adoption of welding and that greater care in design is called for than with riveted construction. Graphs show the incidence of ship structural failure on the basis of year of casualty and of year of build and reveal the decline of casualties since 1943. After expressing the thought that the welded ship is less immune to minor structural failures, the paper goes on to consider still water bending moments for ships with machinery amidships, two-thirds aft and right aft. Draught forward is related to the incidence of slamming and the ability of riveted structure to relieve high stress concentrations by a slight movement within itself. Discontinuities at the strength deck are mentioned and examples of hatchway corner arrangements illustrated and commented upon. Various design details and procedure receive attention and there are remarks concerning questions of corrosion and repair.

RECIPROCAL AGREEMENTS ON SOCIAL SECURITY.—Reciprocal agreements on social security between the United Kingdom and the Federal German Republic were signed in London last week. On the United Kingdom side the agreements apply to Great Britain, Northern Ireland and the Isle of Man. One agreement covers unemployment insurance and assistance. It will enable people who go from one country to the other to have their records of employment and insurance contributions in both countries taken into account if they become unemployed and have to claim benefit in either country. The other agreement covers all other National Insurance and Industrial Injuries benefits. It provides for insurance in both countries to be taken into account when a person claims benefit under the scheme of either country. Each country also undertakes to pay certain benefits in the other country to people who have qualified for them. A protocol on health services entitles people who go from the United Kingdom to Germany for employment, and certain groups of national insurance beneficiaries to take advantage of the German health services in return for the facilities available to Germans in this country. The agreements will not come into effect until they have been ratified.

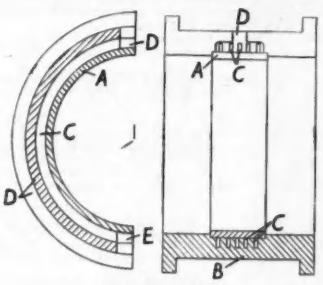
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

BEARINGS AND SUPPORTS

761, 596. April 20, 1954.—BEARINGS, The Parsons and Marine Engineering Turbine Research and Development Association, Pametrada Research Station, Wallsend. (*Inventor: Arthur Derek Newman.*)

The invention relates to sliding bearings, e.g. journal bearings and thrust bearings, its object being to provide improved forms of bearings in which the functions of lubricating and cooling of the working fluid are separated. The drawing shows the invention applied to a journal bearing. Each bearing surface member *A* is composed of porous sintered metal and is supported in a casing *B* with one or a number of annular ducts *C* communicating at the top of the casing with a coolant supply cavity *D* and at the bottom with a coolant drainage cavity *E*. Means are provided for continuously supplying coolant liquid having lubricating properties to the annular ducts *C* whereby the exterior of the bearing surface members *A* adjacent to the ducts are washed by liquid thereby cooling the bearing surface members *A*. In addition to cooling, lubrication is also achieved by capillary flow of a relatively small proportion of the lubricant through the pores of the bearing surface member. According to a modification, a solid



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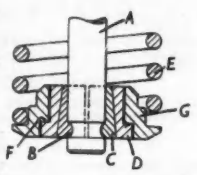
lubricant, such as molybdenum disulphide is applied to or is contained in the bearing surface member; in this case the cooling medium does not need to have lubricating properties.—*November* 14, 1956.

INTERNAL COMBUSTION ENGINES

761,405. June 15, 1954.—POPPET VALVES, Valves, Ltd., Parkside, Coventry. (*Inventors: Walter Joseph Elliott and Geoffrey Raymond Clarke.*)

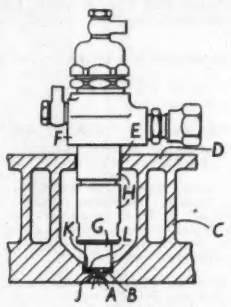
The invention relates particularly to poppet valves for internal combustion engines, its object being to promote free rotation of the valve relative to the valve spring retaining collar, without undue weakening of the valve stem, and in a manner which will allow of the hardening of the bearing faces which are subject to most wear. In the construction illustrated in the drawing, the valve stem *A* has adjacent its end remote from the head, a circumferential groove *B* of substantially semi-circular cross-section. Within this groove is engaged a rib formed on the internal periphery of a two-part split collar *C*, and having a truncated conical external periphery. Surrounding this split collar *C* is an abutment collar *D* which holds the rib of the split collar in firm engagement with the groove *B* under the thrust of the spring *E*. The abutment collar *D* has a shoulder *F*, and is surrounded by a spring-retaining collar *G*. The collars *D* and *G* are hardened and the shoulders are manufactured to a size and surface finish which will facilitate the relative rotation between the collars.—*November* 14, 1956.



No. 761,405

762,222. April 14, 1954.—ENGINES OF THE AIR-COOLED, LIQUID-FUEL-INJECTION, COMPRESSION-IGNITION TYPE, Ricardo and Co., Engineers (1927), Ltd., 21, Suffolk Street, Pall Mall, London, S.W.1. (*Inventors: Donald Biggs and Leslie Ronald Church Lilly.*)

The invention relates to air-cooled, liquid-fuel-injection, compression-ignition engines, and has for its object to provide an engine in which the cooling of the fuel injection nozzle associated with the cylinder or each cylinder will be improved. In the embodiment of the invention shown in the drawing, a cylinder head for an air-cooled compression-ignition engine has formed in it a fuel-injection aperture *A* leading into the combustion chamber and having its outer end surrounded by a flat annular seating *B*. The head is provided with cooling fins *C* integral with which is an upper web *D* referred to as the steadying web, and in which is formed a bore *E*, air being free to flow over the fins *C* and both sides of the steadying web. Fitted in the cylinder head is a nozzle holder or main body portion *F* having a nozzle *G* of relatively small diameter connected to it by a cap nut *H*. The nozzle has an injection orifice *J*, around which is formed an annular seating *K* arranged to make sealing contact through a washer *L* with the annular seating *B* on the cylinder head. It will be



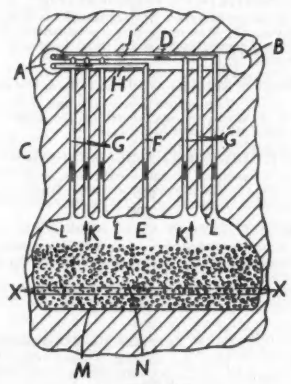
No. 762,222

seen that when in position the steadying web *D* locates the upper part of the nozzle holder and ensures that when clamping means are applied to secure the nozzle holder to the cylinder head it is correctly located. The annular seating *B* is arranged at the base of a frusto-conical recess in the outer wall of the cylinder head so that the length of the injection aperture *A* is kept as short as possible. Further, the end of the injection aperture is of a frusto-conical shape to ensure that the fuel spray from the injection nozzle has an unobstructed flow. With the invention substantially the whole of the nozzle member *F* lies in a space to which cooling air can be ducted by means of baffles or otherwise so as to provide quite adequate cooling.—*November* 28, 1956.

MINING ENGINEERING

762,484. August 26, 1953.—THE UNDERGROUND GASIFICATION OF COAL, The Minister of Fuel and Power, London. (*Inventor: Cyril Aubyn Masterman.*)

The main object of the invention is to provide an underground gasification system which operates in such a manner that not only is the gasifying medium kept in contact with the coal face for as long as the gasifying operation proceeds but also the said gasifying medium has access to the coal face unobstructed by ash and debris. In the drawing, *A*



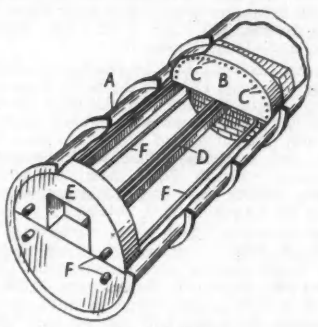
No. 762,484

and *B* indicate the bottoms of vertical shafts leading down to the coal *C* from ground level, the points being connected by a horizontal gallery *D*. The area of the system where the coal is being gasified is indicated by *E*. The reaction is supported by a gasification medium introduced through an inlet borehole *F* and the products of combustion are withdrawn through the outlet boreholes *G*. The inlet borehole is connected to suitable ducts *H* and *J* respectively, which extend through the gallery *D* and are brought to the surface through the shaft *A*. The dotted lines X indicate the position that the reaction zone initially occupied. As gasification proceeds the active reaction area moves slowly in the direction of the arrows *K*. The active reaction face is indicated by *L* and as the face consists of unburnt solid coal the roof of the area *E* is well supported near this face and subsidence does not occur to any extent. On the other hand, on the opposite side *M* of the area *E* the roof is no longer supported and subsidence occurs filling this side with debris as shown at *N*. But as this debris collects on the far side of the reaction zone, the boreholes *F* and *G* remain unobstructed. It will be seen that a second vertical shaft, shaft *B* in the drawing, is not essential in the formation of a system operating in accordance with the invention, and constructional costs may be reduced by providing a single shaft which serves to carry both inlet and outlet ducts. Modified constructions are also described in the specification.—*November* 28, 1956.

STEAM GENERATORS

762,459. November 7, 1952.—IMPROVEMENTS TO BOILERS OR FURNACES, Leonard Barnett, of Viceroy Works, Low Fields Road, Leed, 12.

The invention relates to boilers or furnaces of the horizontal or "Lancashire" type and has reference to the supplying of preheated secondary air over the top of the fire bed for the purpose of producing more



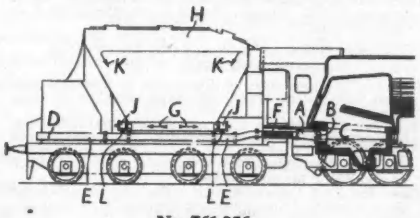
No. 762,459

efficient and complete combustion. Referring to the drawing the boiler *A* has a pre-heating chamber *B* at the bridge end within the furnace, which has numerous outlets *C* arranged to deliver preheated secondary air forward over the fire bed *D* in conjunction with a similar preheating box *E* at the front which takes the place of the normal crown and/or cheek baffles and has outlets similar to those in the preheating box *B*. The preheating boxes or chambers *B* and *E* have air inlets which are coupled by pipes *F* to a common valve-controlled air intake and may operate on forced, induced or natural draught. Alternatively, the preheating box or chambers may have separate valve-controlled air intakes, so that preheated air can be delivered in the boiler or furnace from either or both ends and at a selected velocity or quantity to maintain very accurate control. The front preheater can conveniently be of the construction shown in the prior Specification No. 570,571, whilst the rear one would be similar in size and shape and located at the fire bridge end so as to be adequately heated by the hot furnace gases.—*November* 28, 1956.

RAILWAY ENGINEERING

761,956. December 3, 1954.—CONVEYING COAL DUST FUEL FROM BUNKER TO BURNER, Deutsche Reichsbahn, Technisches Zentralamt, 17/20, Krausenstrasse, Berlin, W.8, Germany. (*Inventor: Hans Wendler.*)

The invention concerns a device for conveying coal dust fuel from bunker to burner primarily in locomotives. The burner *A* feeds the fuel into the hearth *B*, and it burns in the box *C*. Air for combustion is supplied to the burner through pressure which can be the air feed used for the powdered fuel, via the pipe *D*, injection pipe *E*, and coupling *F*. Two pressure nozzles *G* on the floor of the bunker *H* are arranged so that the dust fuel is conveyed to the distributing members *J*. The nozzles can be located at any suitable position to ensure that dust passes



No. 761,956

even when the level in the bunker is low. Additional nozzles, such as indicated at *K*, also are provided, the pressure of these being arranged so that a sufficient pressure is present on the top of the dust to consolidate it to some extent in the bunker, and prevent the formation of voids in the bulk of dust. The coal dust is therefore fed to the distributing members *J* and passes from these devices through down pipes *L* to venturi injection devices *E*, the suctional effect of which further assists in the transport of the dust.—*November* 21, 1956.

Launches and Trial Trips

BOSTON VALETTA, trawler; built by John Lewis and Sons, Ltd., for the Don Fishing Company, Ltd.; length overall 122ft, breadth 24ft, depth 11ft 6in, gross tonnage 239; fish-room 6500 cubic feet, 100 b.h.p. trawl winch of 1200 fathoms, 2¼in warp barrel capacity; one 20kW diesel-driven generator, one 20kW shaft-driven generator, one 82½kW trawl winch diesel-driven generator; one Widdop G.M.B.6 diesel engine, 660 b.h.p. at 300 r.p.m.—Trial, October 12.

ALMERIAN, cargo liner; built by The Caledon Shipbuilding and Engineering Company, Ltd., for Ellerman and Bucknall Lines, Ltd.; length overall 377ft, breadth moulded 53ft, depth moulded to shelter deck 32ft 9in, deadweight 5348 tons, speed 13¼ knots; five cargo holds, one 35-ton, two 10-ton, eight 7-ton and two 5-ton derricks, steam winches; one 33kW and two 25kW steam-driven generators; one triple expansion steam engine and a Bauer-Wach exhaust turbine, 3500 i.h.p. at 92 r.p.m., three oil-fired boilers.—Trial, October 16.

KINGSTON, collier; built by The Burntisland Shipbuilding Company, Ltd., for the South Eastern Gas Board; length between perpendiculars 261ft 6in, breadth 39ft 6in, depth moulded 18ft 6in, deadweight 2875 tons, draught loaded 17ft 1in; three holds, electric deck machinery, three 40kW diesel-driven generators; British Polar diesel engine, eight cylinders, 340mm diameter by 570mm stroke, 1150 b.h.p. at 225 r.p.m.—Launch, October 19.

ALBY, oil tanker; built by the Netherlands Dock and Shipbuilding Company for Biorn Bionstad, Oslo; length between perpendiculars 630ft, breadth moulded 86ft, depth 45ft, displacement 40,000 tons, speed 16·9 knots; thirty cargo oil tanks, one main cargo pump room, four 1000 tons per hour turbine-driven horizontal centrifugal pumps; one set of Parsons geared turbines of 13,750 s.h.p., steam supplied at 600 lb per square inch and 800 deg. Fah. by two Babcock and Wilcox boilers.—Launch, October 20.

ALAN EVELYN, oil tanker; built by the Furness Shipbuilding Company, Ltd., for the British Oil Shipping Company, Ltd.; length overall 661ft 7in, length between perpendiculars 630ft, breadth moulded 87ft, depth moulded 45ft 6in, deadweight 32,000 tons on 34ft 2in summer draught, trial speed 15½ knots; thirty cargo oil compartments, one main cargo pump room, four 900 tons per hour turbine-driven centrifugal cargo pumps, four 150 tons per hour stripping pumps; two 550kW turbine-driven alternators; one set of Metropolitan-Vickers double reduction geared turbines, 12,500 normal s.h.p. at 105 propeller r.p.m., two Foster-Wheeler "D" pattern boilers supply steam at 600 lb per square inch and 850 deg. Fah.—Launch, October 22.

BEECHWOOD, oil tanker; built by Joseph L. Thompson and Sons, Ltd., for John I. Jacobs and Co., Ltd.; length between perpendiculars 597ft 6in, breadth moulded 79ft, depth moulded 46ft 4in, summer draught 34ft, deadweight 27,400 tons; service speed 14 knots; nine centre and eighteen wing cargo oil tanks, two pump rooms; Doxford oil engine, six cylinders 750mm diameter by 2500mm combined stroke, 7750 b.h.p. at 103 r.p.m.—Launch, November 1.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF MINING ELECTRICAL AND MECHANICAL ENGINEERS

Tues., Jan. 8.—LONDON BRANCH: 21, Bloomsbury Street, London, W.C.1, "Dangers Caused by Mechanical Plant at Mines and Quarries," A. E. Crook, 5.45 p.m.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Tues., Jan. 1.—LUTON BRANCH: Chamber of Commerce, George Street West, Luton, "Interference Suppression," A. P. Hale, 8 p.m.

Wed., Jan. 2.—BRIGHTON, HOVE AND DISTRICT BRANCH: New Imperial Hotel, First Avenue, Hove, "A.C. Industrial Control Gear," S. H. Harding, 7.30 p.m.——PRESTON BRANCH: R.A.F.A. Club, East View, Preston, "Electronic Motor Control," K. J. Martin, 7.30 p.m.

Thurs., Jan. 3.—S. LONDON BRANCH: Half Moon Hotel, Broad Green, Croydon, "Specialised Spot Welding," C. G. Aldridge, 8 p.m.

Fri., Jan. 4.—LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "The Diesel Engine," R. V. Hughes, 7.30 p.m.

Mon., Jan. 7.—LEEDS BRANCH: Great Northern Hotel, Leeds, Films, 7.30 p.m.——N.E. LONDON BRANCH: Angel Hotel, Ilford, "Electricity as Applied to the Aircraft Industry," C. G. Hayward, 7.30 p.m.——SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, Film Show, 7.30 p.m.

BELFAST ASSOCIATION OF ENGINEERS

Wed., Jan. 9.—College of Technology, Belfast, "The Early History of Hydraulic Machinery," H. G. Conway, 7.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Tues., Jan. 8.—Management House, 8, Hill Street, London, W.1, "New Fields for Quality Control," R. M. Belbin, 6.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Jan. 2.—MERSEYSIDE SECTION: Chamber of Commerce, 1, Old Hall Street, Liverpool, 3, "Instrumentation for Frequency Modulation," D. R. Willis and A. G. Wray, 7 p.m.

Thurs., Jan. 3.—N.W. SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "Projection Television Systems," C. Somers, 6.30 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Jan. 5.—Caxton Hall, Caxton Street, London, S.W.1, "Astronomy and Earth Satellites," Michael W. Ovenden, 6 p.m.

ELECTRICAL POWER ENGINEERS' ASSOCIATION

Mon., Jan. 7.—LONDON TECHNICAL GROUP: Caxton Hall, Westminster, London, S.W.1, "Radioactive Techniques in Industry," J. L. Putman, 7 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., Jan. 1.—BIRMINGHAM CENTRE: College of Technology, Suffolk Street, Birmingham, Display of Lighting Fittings, 6 p.m.

Thurs., Jan. 3.—CARDIFF CENTRE: S. Wales Electricity Board's Demonstration Theatre, The Hayes, Cardiff, "Streetlighting and South Wales," F. H. Pulvermacher: "Eye Appeal," W. G. Sweet, 7 p.m.——NOTTINGHAM CENTRE: Electricity Service Centre, Smithy Row, Nottingham, "Lighting of Standard Factories on Trading Estates," J. S. McCulloch, 5.30 p.m.

Tues., Jan. 8.—SESSIONAL MEETING: Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "Lighting as an Effective Aid to Architecture," H. R. Ruff, H. E. Bellchambers and R. V. Mills, 6 p.m.

INCORPORATED PLANT ENGINEERS

Wed., Jan. 2.—SOUTHERN BRANCH: Polygon Hotel, Southampton, "Ship Construction," 7.30 p.m.

Thurs., Jan. 3.—PETERBOROUGH BRANCH: White Lion Hotel, Church Street, Peterborough, "Dust Control," R. J. Pitt, 7.30 p.m.

Tues., Jan. 8.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "Acoustics and Vibration," W. A. Hines, 6.30 p.m.——EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "Electronics in Industry," R. B. Smith, 7 p.m.——MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Floor Loadings," S. C. Swan, 7.15 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Mon., Jan. 7.—LANCASHIRE BRANCH: Midland Hotel, Manchester, "Co-operation and Co-ordination between Pattern Shop and Foundry," E. H. Beech and N. Bradshaw, 7 p.m.——SHEFFIELD BRANCH: College of Commerce and Technology, Department of Engineering, Pond Street, Sheffield, "Foundry Maintenance," G. L. Jenkins, 7 p.m.

INSTITUTE OF METALS

Thurs., Jan. 3.—BIRMINGHAM LOCAL SECTION: Exchange and Engineering Centre, Stephenson Place, Birmingham, Discussion on "Timber versus Metals," opening speakers D. O. Reece, W. E. Ballard and Dorothy Pile, 6.30 p.m.——LONDON LOCAL SECTION: 17, Belgrave Square, London, S.W.1, "The Metallurgical Challenge of Nuclear Power," H. K. Hardy, 6.30 p.m.

Tues., Jan. 8.—OXFORD LOCAL SECTION: Cadena Cafe, Cornmarket Street, Oxford, "Gases in Metals," C. E. Ransley, 7 p.m.

INSTITUTE OF PETROLEUM

Wed., Jan. 2.—26, Portland Place, London, S.W.1, Symposium on Staff Training, 5.30 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Jan. 3.—JOINT MEETING: Junior Institution of Engineers, Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Thermal Properties of Heat Insulation at Low Temperatures," M. J. Hickman, 5.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Jan. 8.—6, Buckingham Gate, London, S.W.1, "The Economics of Machinery Investment on the Farm," F. G. Sturrock and J. R. Warburton, 5.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Jan. 8.—Geological Society, Burlington House, London, W.1, "Solution of the Equations for Mass-Transfer in Plate-Type Distillation Columns," H. H. Rosenbrock, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 8.—ROAD MEETING: Great George Street, Westminster, London, S.W.1, "Organisation and Control of Highways Maintenance," W. J. Hiscock, 5.30 p.m.

Wed., Jan. 9.—A.L.G.S. MEETING: Great George Street, Westminster, London, S.W.1, "Inland Waterways," C. M. Marsh, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 7.—S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Recruitment to the Engineering Profession," 6 p.m.

Tues., Jan. 8.—MEASUREMENT AND RADIO SECTION: Savoy Place, London, W.C.2, "A Theoretical and Experimental Investigation of Anisotropic-Dielectric-Loaded Linear Electron Accelerators," R. B. R.-Shersby-Harvie, L. B. Mullett, W. Walkinshaw, J. S. Bell and B. G. Loach, 5.30 p.m.

Wed., Jan. 9.—N. SCOTLAND SUB-CENTRE: Caledonian Hotel, Aberdeen, "Colour Television," G. N. Patchett, 7.30 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Jan. 9.—St. Bride Institute, Bride Lane, Fleet Street, London, E.C.4, "Automatic Level Control in Boilers," Sir Harold Roxbee Cox, 6 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Mon., Jan. 7.—N.E. COAST BRANCH: Institute of Mining and Mechanical Engineers, Neville Street, Newcastle upon Tyne, 1, "Some Notes on the Choice of Mechanical Stokers for Boiler Plants," E. J. C. Macdonald, 6.30 p.m.

Wed., Jan. 9.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Mechanical Services in the Central Area of London Airport," R. E. Tully, 6 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Thurs., Jan. 3.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Films, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Wed., Jan. 2.—APPLIED MECHANICS GROUP DISCUSSION: 1, Birdcage Walk, Westminster, London, S.W.1, "New Techniques in Photo-Elasticity," 6.45 p.m.——MIDLAND GRADUATES' SECTION: W. Midlands Gas Board, Darlington Street, Wolverhampton, "Heavy Haulage and its Ancillary Work," E. Bulgin, 7.30 p.m.

Thurs., Jan. 3.—WESTERN A.D. CENTRE: Royal Hotel, Bristol, Film Evening, 6.45 p.m.——YORKSHIRE GRADUATES' SECTION: Mining Lecture Theatre, The University, St. George's Square, Sheffield, "Patenting an Invention," C. Lees, 6.30 p.m.

Fri., Jan. 4.—GENERAL MEETING IN CONJUNCTION WITH THE APPLIED MECHANICS' GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "An Experimental Investigation of the Process of Expanding Boiler Tubes," J. M. Alexander and Hugh Ford, 6 p.m.

Tues., Jan. 8.—AUTOMOBILE DIVISION GENERAL MEETING IN CONJUNCTION WITH THE HYDRAULICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "A Review of Hydro-Kinetic Fluid Drives and their Possibilities for the British Motor Industry," J. G. Giles, 6 p.m.

Wed., Jan. 9.—E. MIDLANDS BRANCH: College of Technology and Commerce, Leicester, Annual Meeting, "A Standard Gas Turbine to Burn a Variety of Fuels," G. B. R. Feilden, J. D. Thorn and M. J. Kemper, 7.15 p.m.——YORKSHIRE GRADUATES' SECTION: Visit to Redfern Brothers, Ltd., Glassworks, Barnsley, 6.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Mon., Jan. 7.—ORDINARY MEETING: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Auto. Exch. Maintenance Procedure: Past, Present and Future," S. Rudeforth, K. S. Laver and E. R. Driver, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Thurs., Jan. 3.—READING SECTION: Social Club, Petters, Ltd., Staines, "Application of Accurate Measurement to Engineering Production," J. Loxham, 7.30 p.m.

Tues., Jan. 8.—LONDON GRADUATE SECTION: 10, Chesterfield Street, London, W.1, "Broaches and Broaching," W. E. Soden, 7.15 p.m.

Wed., Jan. 9.—LIVERPOOL SECTION: Bradford Hotel, Tithebarn Street, Liverpool, "Cutting Tools: Application and Research," M. O. Short, 7.30 p.m.——PRESTON SECTION: College of Further Education, Sandy Lane, Accrington, "The Manufacture and Application of Ball and Roller Bearings," R. W. Jones, 7.15 p.m.——S. ESSEX SECTION: Mid-Essex Technical College, Chelmsford, "Electronic Computer Control of Machine Tools," 7.30 p.m.——WOLVERHAMPTON SECTION: Technical College, Wolverhampton, "Industrial Research," P. Spear, 7.15 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Thurs., Jan. 3.—SOUTHERN SECTION: The University, Southampton, "Block Polymer Production by Mechanical Energy," W. F. Watson, 7.30 p.m.

Mon., Jan. 7.—N.E. SECTION: Eldon Grill, Grey Street, Newcastle, Film Evening, 7 p.m.

Tues., Jan. 8.—LONDON SECTION: Royal Society of Tropical Medicine and Hygiene, 26, Portland Place, London, W.1, "Electronic Force Measurement in Rubber Testing," A. E. Eagles and A. R. Payne, 7 p.m.; "Phenolic Resins as Reinforcing Agents," S. M. Ardley, 5.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Fri., Jan. 4.—WESTERN COUNTIES BRANCH: New Engineering School, The University, Bristol, "The Advantages and Disadvantages of Structural Steelwork, Reinforced Concrete and Prestressed Concrete," Donovan H. Lee, 6 p.m.

Tues., Jan. 8.—LONDON GRADUATES' AND STUDENTS' SECTION: 11, Upper Belgrave Street, London, S.W.1, Address by the President, J. Guthrie Brown, 6.30 p.m.——N. IRELAND BRANCH: College of Technology, Belfast, "Developments in Prestressing Equipment," 6.45 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Wed., Jan. 2.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Chairman's Address, J. H. Price, 7 p.m.

Thurs., Jan. 3.—N.W. SECTION: Reynolds Hall, College of Technology, Manchester, "Projection Television Receivers," I. Somers, 6.30 p.m.

Fri., Jan. 4.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Film Evening, 7 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., Jan. 9.—24, Dale Street, Liverpool, "Mineral Insulated Metal-Sheathed Cables," J. A. McCleery, 6 p.m.

NEWCOMEN SOCIETY

Wed., Jan. 9.—Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1, "The Crampton Locomotive: Part II," P. C. Dewhurst, 5.30 p.m.

PLASTICS INSTITUTE

Wed., Jan. 2.—LECTURE FOR YOUNG PEOPLE: Church House, Westminster, London, S.W.1, "Plastics and the Engineer," J. Butler, 2.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Jan. 3.—YOUNG PEOPLE'S LECTURE: Royal Society of Arts, John Adam Street, London, W.C.2, "Experiences of an Airline Pilot," O. P. Jones, 3 p.m.

Tues., Jan. 8.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "The Significance of Flow Separation in Three Dimensions," C. Maskell, 7 p.m.

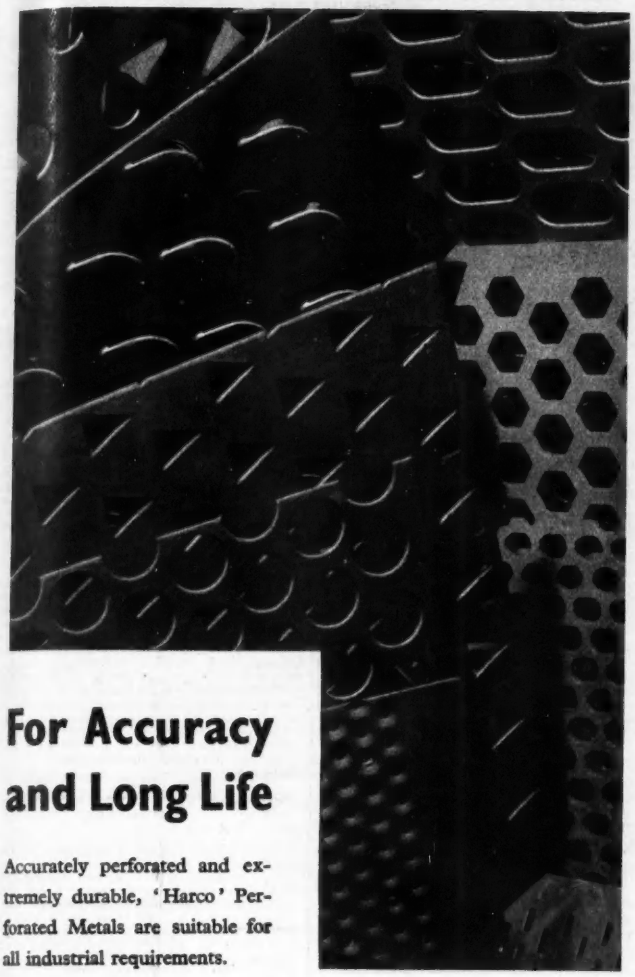
ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Jan. 7.—ORDINARY GENERAL MEETING: 12, Great George Street, London, S.W.1, "The Heating of Buildings by Warm Air," W. Davidson, 5.45 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., Jan. 9.—CORROSION GROUP: 14–16, Belgrave Square, London, S.W.1, "Corrosion Problems in Nuclear Power Production," A. B. McIntosh, 6.30 p.m.

END OF VOLUME 202



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PUBLIC APPOINTMENTS

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE

GEORGE ANGUS STUDENTSHIP

Applications are invited for the above-mentioned STUDENTSHIP, of the value of £350 per annum, which is available annually for post-graduate research in the Department of either Chemistry, Physics, or Mechanical Engineering, as a result of a gift from Messrs. George Angus and Co., Ltd., of Newcastle upon Tyne.

The Studentship is open to graduates of approved universities, or the holders of approved qualifications. It is tenable for two years, but may be renewed for a third year in special circumstances.

Forms of application and further particulars may be obtained from the undersigned, to whom completed application forms must be returned by the 31st January, 1957.

E9432 G. R. HANSON, Registrar of King's College.

QUEEN MARY COLLEGE (UNIVERSITY OF LONDON) MILE END ROAD, E.1

LECTURESHIP IN MECHANICAL ENGINEERING

Queen Mary College (University of London), Mile End Road, E.1, invites applications from University Graduates for a LECTURESHIP IN MECHANICAL ENGINEERING. Applicants should have a good Engineering Degree and some experience in industry and research. Salary scale: £700 by £50 to £1000 by £50 to £1400, initial salary according to qualifications and experience, with F.S.S.U. participation and family allowance of £50 for each child. Application forms, to be returned within two weeks of appearance of this advertisement, obtainable from the Registrar. E9411

AIR MINISTRY

WORKS DEPARTMENT

MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require MECHANICAL AND ELECTRICAL ENGINEERS in Works Department, for design, operation and maintenance of mechanical and electrical services on R.A.F. stations at home and overseas and Civil Aviation stations.

Appointments in: (i) Main Grade, salary scale £1215–£1640 (London rate); (ii) Assistant Grade, according to age, £765 at 25, to £1030 at 34 or over, rising to maximum £1190 (London), with promotion prospects. Salaries somewhat lower in Provinces. Appointments non-pensionable but with pensionable prospects. Five-day week with 4–6 weeks' leave a year, according to grade and length of service. Special allowance up to £1500 a year, according to location, payable in addition to salary during overseas service. Candidates normally must be natural born British subjects of natural born British parents, and age 25 or over.

Minimum qualifications and experience: (i): (a) University Degree or equivalent diploma in Electrical and/or Mechanical Engineering, with at least 2 years' apprenticeship; or (b) Graduate or Corporate Member of I.E.E., with at least 3 years' apprenticeship; or (c) Graduate or Corporate Member of I.Mech.E., appreciable electrical engineering experience, with at least 3 years' apprenticeship. (ii) Have been employed for minimum of three years with well-established engineering concern and gained wide experience in both electrical and mechanical engineering practice. Forms quoting reference D 306/6A, from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1. E9269

LONDON TRANSPORT

CHARTERED CIVIL ENGINEER

London Transport require CHARTERED CIVIL ENGINEER for work in connection with New Works Programme. Applicants must have professional and administrative experience and be able to organise and control a section of the office.

Applicants should have experience in some of the following types of civil engineering work:—Earthworks, bridging, general railway construction, heavy foundations, R.C. works and tunnelling. They should be able to prepare schemes, contract drawings and documents and supervise contract works.

Salary range £1150 to £1350; medical examination, free travel.

Applications within 14 days to Recruitment and Training Officer (F/EV 600), London Transport, 55 Broadway, S.W.1. E9429

NATIONAL COAL BOARD

EAST MIDLANDS DIVISION

AREA MECHANICAL ENGINEER

National Coal Board, East Midlands Division, have a vacancy for an AREA MECHANICAL ENGINEER in their No. 4 Area.

Applicants should be members of an appropriate professional body or possess other suitable technical qualifications and must have had extensive practical experience in Colliery Mechanical Engineering, and be fully conversant with design, installation, operation and maintenance of Colliery Plant and Machinery.

Applications to be addressed to: Staff Director, National Coal Board, East Midlands Division, Sherwood Lodge, Arnold, Nr. Nottingham, within 14 days. Please quote S.V.675 on envelopes and applications. E9408

PUBLIC APPOINTMENTS

LANCASHIRE RIVER BOARD

APPOINTMENTS

Applications are invited for the following superannuable appointments from applicants with the qualifications and experience indicated :—

ASSISTANT ENGINEER.—A.P.T. IV and V (£727 15s. to £994 5s. p.a.).

Final professional qualifications, considerable experience in design and execution of new and improved land drainage works in agricultural and urban areas. Successful applicant will be required to provide a car, for which an allowance will be paid in accordance with the National Joint Council scales up to a maximum of 1399 c.c.

ASSISTANT ENGINEER (Hydrology and River Gauging).—A.P.T. III and IV (£656 to £907 2s. 6d. p.a.).

Final professional qualifications or Graduate Membership of the Institution of Civil Engineers or University Graduateship with at least five years' experience, including period of theoretical training. Experience of river gauging and practical application of hydrology to land drainage problems. Successful applicant will be required to provide a car, for which an allowance (as stated above) will be paid.

ENGINEERING ASSISTANTS (2).—A.P.T. I and II (£543 5s. to £691 17s. 6d. p.a.).

Section A at least of the Institution of Civil Engineers, sound training and preferably experience of land drainage engineering. Applicants for one of the posts must also be competent surveyors and draughtsmen. For the other post preferably experience of river gauging and hydrology. It would be an advantage for an applicant to be able to provide a car, for which an allowance (as stated above) would be paid.

All the appointments are subject to the Conditions of Service applicable from time to time to staff of the Board, including the National Conditions of Service. Successful applicants will be required to pass satisfactorily a medical examination.

Applications, stating age, marital status, position regarding National Service, qualifications, technical training, experience, present and previous appointments with salaries, together with the names of two persons to whom reference may be made, should reach the Chief Engineer of the Board at the undermentioned address not later than the 21st January, 1957.

Canvassing, directly or indirectly, will disqualify.

H. HOLMES,
Clerk of the Board.

48, West Cliff, Preston. E9338

LIVERPOOL REGIONAL HOSPITAL BOARD

REGIONAL ENGINEER

Applications are invited for the post of REGIONAL ENGINEER. Candidates, who should be Corporate Members of the Institution of Mechanical Engineers or the Institution of Electrical Engineers, must have had wide experience of engineering design and operation, preferably for hospitals or other large undertakings.

The Regional Engineer will be required, inter alia, to undertake the design and supervision of capital projects in the Board's major plant replacement programme and of new engineering works for which the Board is responsible (subject to the employment in some cases of consultant engineers), and to advise Hospital Management Committees on engineering problems.

The salary scale is £1690 by £80 (5) by £45 (1) to £2135 per annum, and the post is superannuable.

Applications, stating age, qualifications and experience, together with the names of three referees, should reach the undersigned not later than 5th January, 1957.

VINCENT COLLINGE,
Secretary to the Board.

19, James Street,
Liverpool, 2. E9382

PRISON COMMISSION

CIVILIAN INSTRUCTIONAL OFFICER

CIVILIAN INSTRUCTIONAL OFFICER, Engineering Fitter Machinist, required for General Engineering Workshop, at H.M. Prison, Wormwood Scrubs, London, W.12.

Applicants must be at least 30 on 25 January, 1957, and have served a full apprenticeship followed by not less than 5 years' industrial experience. Possession of a Final City and Guilds Certificate or equivalent and some teaching experience would be considered additional qualifications.

Salary £746, rising by four annual increments to a total of £863 inclusive, payable monthly ; 44-hour week, 18 working days paid annual holiday, rising to 24 days after three years' service, plus the usual public holidays ; quarters not provided. Appointment non-pensionable, but establishment considered after period of satisfactory service.

Application forms, returnable by 11 January, 1957, may be obtained from Establishment Officer (E 204/146), Prison Commission, Horseferry House, Dean Ryle Street, London, S.W.1. E9428

LANCASHIRE COUNTY COUNCIL

ELECTRICAL ENGINEER

Applications are invited for the permanent appointment of ELECTRICAL ENGINEER, within the salary scale £814 17s. 6d. to £994 5s. Applicants should be Corporate Members of the Institution of Electrical Engineers or have passed the qualifying examination for such qualification, and have had a wide experience in the design of electrical light and power installations in all classes of buildings, and should have had industrial experience.

Application forms from the County Architect, P.O. Box 26, County Hall, Preston, to be returned by Friday, 11th January, 1957, quoting reference A/E. E9386

PUBLIC APPOINTMENTS

COMMONWEALTH OF AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION

DIVISION OF FOOD PRESERVATION AND TRANSPORT

APPOINTMENT NO. 300/188 OF PHYSICIST/ENGINEER

Applications are invited for appointment to a position of PHYSICIST/ENGINEER in the Physics Section of the Division of Food Preservation and Transport located at Homebush, New South Wales.

The Division has in progress a wide range of investigations of fundamental problems related to food and work on the technology of cold storage, freezing, canning and dehydration. The Physics Section undertakes a variety of long-term and short-term investigations related to the work of the Division and many of these involve problems of heat and water transfer. The appointee will be asked to undertake investigations on the water loss from foods in cold storage and also to take part, from time to time, in short-term studies which will often be in collaboration with other sections of the Division and to design special equipment required in the laboratory.

The appointee will be classified as Research Officer or Senior Research Officer, and according to qualifications and experience, commencing salary will be determined within the salary ranges of £A1287–£A1912 p.a. (actual) or £A2022–£A2297 p.a. (actual). Commencing salary for a female appointee would be £A160 p.a. less than the corresponding male figures.

Applicants should possess a University Honours Degree in Mechanical Engineering, Chemical Engineering or Science, with sound training in the principles of heat transfer, preferably including some research experience in this field.

First-class sea fares to Australia will be paid for the appointee, his wife and family.

The appointment will be conditional on a satisfactory medical examination and the successful applicant will be required to contribute to, and eligible to receive benefits from, either the Commonwealth Superannuation Fund or the Commonwealth Provident Account.

Applications, referring to Appointment No. 300/188 and stating full name, place, date and year of birth, marital state, nationality, present employment, particulars of qualifications and experience, and of war service, if any, accompanied by copies of not more than four testimonials, and the names and addresses of at least two persons willing to act as referees, should reach the undersigned, from whom additional information may be obtained, not later than the 31st January, 1956.

A. SHAVITSKY,
Chief Scientific Liaison Officer.

Australian Scientific Liaison Office,
Africa House,
Kingsway,
London, W.C.2. E9404

BOROUGH OF SHREWSBURY

WATER DEPARTMENT

ASSISTANT ENGINEER, GRADE V-VI

Applications are invited for the above appointment on the permanent staff of the Water Engineer and Manager. Salary : A.P.T. V-VI (£814 17s. 6d. to £1107), according to qualifications and experience.

Candidates must be Corporate Members of the Institution of Civil Engineers and of the Institution of Water Engineers, and must have had considerable experience in the design and administration of Water Engineering work.

Housing accommodation available. Assistance will be given with regard to the successful applicant's removal arrangements.

Particulars of appointment to be obtained from the Water Engineer and Manager, Shelton, Shrewsbury, and to be returned to him by Monday, the 7th January, 1957.

S. R. H. LOXTON,
Town Clerk.

Guildhall,
Shrewsbury. E9409

HALIFAX GENERAL HOSPITAL

SENIOR ENGINEER

Applications are invited for the post of SENIOR ENGINEER at Halifax General Hospital. Applicants must be thoroughly experienced with steam boilers, mechanical and electrical engineering services, and possess a Higher National Certificate in Mechanical Engineering or an equivalent qualification.

Salary £625 per annum by increments to £745 per annum.

Applications, stating age, experience, &c., together with names and addresses of two referees, to be forwarded to Group Secretary, Royal Halifax Infirmary, Halifax. E9390

BRITISH IRON AND STEEL RESEARCH ASSOCIATION

ERGONOMICS SECTION

APPOINTMENT

A vacancy exists in the Ergonomics Section of the British Iron and Steel Research Association for a Graduate to carry out research into the human engineering aspects of the design of control points in steelworks. The work is located in London and the starting salary will be up to £800 p.a., depending on age and qualifications. Post is superannuated under the F.S.S.U. Written applications only, quoting "ERG 1," to the Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1. E9414

PUBLIC APPOINTMENTS

NATIONAL COAL BOARD

WEST MIDLANDS DIVISION

CIVIL/STRUCTURAL ENGINEERS

National Coal Board, West Midlands Division, require CIVIL/STRUCTURAL ENGINEERS.

Location, Divisional Headquarters, Dudley.

Salary within range £800–£1225.

Candidates must be Corporate Members of the Institution of Civil or Structural Engineers and have had experience in the design and construction of some of the following :

Heavy foundations.
Roads and drainage.
Structures in reinforced concrete and structural steel.
Railway sidings.

Experience in preparation of contract documents, specifications and bills of quantities an advantage.

Applications—on forms obtainable from Divisional Chief Staff Officer, West Midlands Divisional Coal Board, Himley Hall, Dudley, Worcs.—to be submitted within 14 days of this date. E9434

TENDERS

NEW TENDERS FOR YALLOURN "E" POWER STATION, VICTORIA, AUSTRALIA.

Notice is hereby given that the date for return of Tenders for Yallourn "E" Power Station has been extended from 13th February, 1957, to 13th March, 1957.

Details of the Tenders were advertised in the issue of this paper dated November 30th, 1956.

STATE ELECTRICITY COMMISSION OF VICTORIA,

22 William Street, Melbourne.

E9400

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29, WRIGHT'S LANE, LONDON, W.8.
E102 E

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FREE ! Brochure giving details of Courses in Mechanical and Production Engineering Draughtsmanship, &c., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other Professional Examinations.—E.M.I. Institutes, Dept. E30, London, W.4 (associated with H.M.V.). E708 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED

A SERVICE MANAGER is required in the Pump and Compressor Division of HAMWORTHY ENGINEERING LIMITED, POOLE, DORSET. The successful applicant will be responsible to the General Manager for all outside work involving installation, test and repair, together with spares and overhaul at the works. Applications are invited from qualified engineers who have served a full engineering apprenticeship and who have had previous service experience. In an expanding company, this is a responsible and progressive appointment where sound administrative and organising ability is clearly necessary and where a marine engineering background is advantageous, although not essential. A contributory superannuation scheme is in operation.—Please write in strict confidence to the Personnel Officer, giving full details of age, apprenticeship, qualifications, experience and present appointment. E9435 A

SITUATIONS VACANT

A MANUFACTURING COMPANY in country town has vacancies for SENIOR ENGINEERING OR DESIGN DRAUGHTSMEN, for work on special projects. Salary offered, £750–£950, according to experience. Permanent jobs with ample scope. Pension and life assurance scheme. 5-day week. Help towards initial accommodation.—BOX No. E9372, "The Engineer." A

A NUMBER OF DESIGNERS AND DRAUGHTSMEN
are required for good-class mechanical engineering work
by
HEENAN & FROUDE LIMITED, WORCESTER.

Applicants should be between the ages of about 25 and 40. Please state education, training, experience and salary required ; special consideration to men with outstanding experience and qualifications. Those used to aircraft test plant, marine, medium and heavy engine designing would be particularly suitable. Pension scheme, attractive surroundings and usual staff amenities. Assistance with housing and removal expenses, if necessary.

Please address your application for the attention of Mr. T. Salter. E9352 A

APPLICATIONS are invited from DESIGNER-DRAUGHTSMEN holding at least O.N.C., but H.N.C. preferred, with some experience of problems connected with heat exchangers, space heating, steam and hydraulic machinery and pipework. Salary according to experience and age. For married men assistance with housing will be given if necessary.—Write, in confidence, stating age, qualifications, experience, and present salary, to EP/ACM, MICHELIN TYRE CO., LTD., Stoke-on-Trent. E9257 A

BRITISH ROPEWAY ENGINEERING COMPANY, LIMITED,

Plantation House, Mincing Lane, E.C.3.

SENIOR DESIGNER - DRAUGHTSMAN required, preferably with experience in design of mechanical handling plant. Interesting opportunity in unusual field of engineering. Offices near London Bridge. Five-day week, pension scheme, luncheon vouchers, Christmas bonus. Also vacancy exists for SENIOR JIG AND TOOL DESIGNER, similar conditions apply.

Write to above, giving details of age, experience and salary required. E9426 A

CHIEF ESTIMATING ENGINEER required, with wide experience on large Contracts involving Mechanical, Electrical and Chemical Engineering Plant and Equipment and Associated Site Erection. Offices are located in Central London, and there is a superannuation scheme. Good salary to first-class man. Please apply, in strict confidence, giving age, experience and when available.—BOX No. E9410, "The Engineer." A

CIVIL ENGINEERING QUARRYING FIRM require PLANT AND TRANSPORT MANAGER for W. London. 25–35 years. £750 starting. Good permanent prospects.—BOX No. E4426, "The Engineer." A

CIVIL ENGINEERS required by Consultants with offices in Glasgow, for work on large hydro-electric projects and steam power stations. Vacancies exist for Assistant Engineers, to be engaged on design and also on site supervision. Applicants must have passed or be exempt from Parts I and II of the Associate Membership examination of the Institution of Civil Engineers. Apply by letter with particulars of age, qualifications and experience.—BOX No. E905, "The Engineer." A

DESIGNERS AND ESTIMATORS with extensive experience of all types of package handling and mechanical handling equipment. Attractive working conditions, contributory pensions scheme, salaries up to £1100 per annum, according to experience.—Apply, with all relevant particulars, to : Modern Mechanisation, Ltd., "Elmswood House," Bounds Green Road, London, N.11. E915 A

DETAIL DRAUGHTSMEN required by Manchester company accustomed to detailing structural and/or mechanical design in connection with coal preparation plant. Pension scheme, canteen. State age, experience and salary required.—BOX No. E9223, "The Engineer." A

DISTRICT (CIVIL) ENGINEER required by British Railway Company operating Chile. Sterling salary, retirement benefits, free quarters, passages, home leave, allowances, &c.—Write to BOX No. 598, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E9405 A

DRAUGHTSMAN (Senior), age about 30/35, required by Pump Manufacturers, for plant layout work in connection with centrifugal pumping schemes. Knowledge of centrifugal pumps most desirable but not essential, depending on other qualifications. Permanent post.—Apply, stating qualifications and salary required, to Works Manager, Lee, Howl and Co., Limited, Tipton, Staffs. E9280 A

DRAUGHTSMEN required for design and detailing of conveyors, elevators, structural steelwork, &c. Some previous experience in this class of work essential and the positions give every opportunity of visiting sites for inspection, measurements, &c.—Apply, W. W. Brown and Partners, Ltd., 72, Newman Street, London, W.1. E918 A

Classified Advts. continued on page 4

SITUATIONS VACANT

DRAUGHTSMEN, with a good experience in mechanical engineering, are required for very interesting work on varied projects being undertaken in the Weston-Super-Mare division of a large engineering organisation. Positions are permanent, salaries above union rates, pension scheme. Please apply, giving full particulars of experience, age and qualifications.—BOX No. E9315, "The Engineer." A

DRAUGHTSMEN (Senior and Junior) required for work in connection with the following branches of coke oven and gasworks plants:—
(a) Mechanical and By-Product Plant.
(b) Pipework.
(c) Steelwork for Buildings and Conveyors.
Applicants should be competent men able to work with the minimum of supervision. Technical qualifications to O.N.C. or beyond. Good remuneration and prospects for capable men. Pension scheme. Five-day week; canteen facilities.—State age and experience to the Personnel Officer (D.O.), Woodall-Duckham Construction Company, Ltd., Woodall-Duckham House, 63–77, Brompton Road, London, S.W.3. E672 A

DRAUGHTSMEN required for interesting work in the electronics field:
(1) Circuitry Draughtsmen.
(2) Checkers for Electronic Equipment.
(3) Design and Detail Draughtsmen for Electronic Equipment.
(4) Design and Detail Draughtsmen for Radar Gear.
These vacancies are with an expanding organisation, and are in the London suburbs (S.W.). Salaries range from £14 15s. to £17 15s., depending on age, experience and qualifications. Pension scheme available. Please apply, quoting reference WEST.—BOX No. E9383, "The Engineer." A

DRAUGHTSMEN required for special-purpose machine design, plant layout or mechanical handling systems. Erdington, Birmingham. Please write, giving experience and salary.—BOX No. E9418, "The Engineer." A

ENGINEER, not over 30, required by British Company for Sales Post in NORTH BORNEO, covering a wide range of engineering products in a rapidly expanding market. It is preferable that applicant should be either G.I.Mech.E. or Grad.I.E.E. Tours, first on remuneration commensurate with ability and experience, thereafter with merit, allow frequent paid home and local leaves. Outfit allowance and accommodation provided. Pension scheme and provident fund.—BOX No. E9415, "The Engineer." A

ENGINEER SURVEYORS for pressure vessel inspection—vacancies in North London and East Lancashire/West Yorkshire. Must possess First Class M.O.T. Certificate (Steam). Salary £675, rising to £1000. Non-contributory pension.—Apply, Engineering Dept., General Accident Assurance Corp., 99, Aldwych, London, W.C.2. E9421 A

ENGINEERING INSURANCE COMPANY invites applications from engineers, not over 35 years of age, who possess First Class M.O.T. Certificate (Steam) for position as ENGINEER SURVEYOR in London and surrounding districts. Progressive salary scale commences at £675, rising to £1000 per annum, plus expenses and allowances. Non-contributory pension scheme and other staff schemes. Apply in own handwriting.—BOX No. E9311, "The Engineer." A

ENGINEERING INSURANCE.—Applications are invited from ENGINEERS not over 35 years of age, having served apprenticeship, with sound theoretical and practical knowledge of cranes and lifting machines, technically qualified to Higher National Certificate standard, for a vacancy in Bristol (West of England). The position is permanent, pensionable, with salary scale £675, rising to £1000 per annum, plus expenses and allowances. Apply in own handwriting.—BOX No. E4413, "The Engineer." A

ENGINEERS, as specified, required by modern well-equipped Rayon Yarn Producers:

PROJECT ENGINEERS (Senior and Junior), Mechanical/Chemical. Minimum qualifications H.N.C. Mechanical and/or Chemical Engineering. These appointments, which are permanent and progressive, will call for the necessary energy and initiative to carry through projects from estimates to commissioning.

JUNIOR MECHANICAL MAINTENANCE ENGINEERS, 27/35. Minimum qualifications H.N.C. Supervisory experience an advantage and dependent on satisfactory work, successful applicants will be given the opportunity to qualify for more senior posts.

These posts all carry good salaries and prospects and are pensionable. Applications, which will be treated in strict confidence, should state education, experience, in chronological order, age and present remuneration, and be addressed to Personnel Manager, British Enka Limited, Aintree, Liverpool, 9. E9349 A

ESSO PETROLEUM COMPANY, LIMITED, have vacancies in their Bristol office for CIVIL ENGINEERING DRAUGHTSMEN. Applicants who should not be over 30 years of age, should have experience in building and/or civil engineering construction. The positions offer opportunities for experience on work of considerable diversity. They are pensionable and all successful applicants will be appointed to the company's regular staff.—Applications, in writing, giving full details of career, qualifications and salary required, to Employee Relations Manager, Esso Petroleum Co., Ltd., Eagle House, St. Stephen's Street, Bristol, 1. E9423 A

ENGINEERS
(ELECTRICAL AND MECHANICAL)
PHYSICISTS
and
TECHNICAL ASSISTANTS
Required for work on development, manufacture and circuit application of special radio valves, including microwave devices.
Minimum qualifications: Inter. B.Sc. or O.N.C.
Experience is desirable but not essential.
Initial training at the research laboratories of The General Electric Company will be available for selected candidates.
These are progressive positions with good opportunities for advancement.
Apply, quoting TC/1, to:—
M.O. Valve Co.,
Osram Works,
Brook Green,
Hammersmith, W.6.
MANUFACTURERS OF VALVES FOR G.E.C. E9407 A

ESSO PETROLEUM COMPANY, LIMITED, have vacancies in London for CIVIL ENGINEERS, MECHANICAL ENGINEERS and DRAUGHTSMEN. Applicants should have served a recognised apprenticeship, should preferably have had experience in the oil or chemical industries, and possess suitable qualifications for the respective positions.—Applications, giving brief details of career, should be made to the Employee Relations Manager, 101, Piccadilly, W.1. E9413 A

EXPERIENCED DRAUGHTSMAN required for the design of Fuel Injection, Hydraulic Equipment and Governors. This is interesting work, with excellent prospects, carrying a good salary and attractive non-contributory pension scheme.—Apply, Chief Personnel Officer, Bryce Berger, Limited, Ironbarks Works, Staines, Middlesex. E910 A

EXPERIENCED OIL ENGINE DESIGNER required, with initiative for work on small engines. Pleasant working conditions, good salary, non-contributory pension scheme.—Apply, Chief Personnel Officer, Petters, Limited, Causeway Works, Staines, Middlesex. E908 A

EXPERIENCED PLANNING ENGINEERS required for production methods on medium I.C. engine components and fuel injection equipments. Pleasant working conditions, generous salary. Attractive pension scheme and comprehensive welfare facilities.—Apply, Chief Personnel Officer, Petters, Ltd., Causeway Works, Staines, Middx. E875 A

FIRST-CLASS ENGINEER required by London Engineering Company, for the design and development of automotive transmissions, &c. Practical and theoretical experience essential. Excellent prospects. Write in full confidence, stating age, experience, qualifications, positions held and salary required.—BOX No. E4412, "The Engineer." A

FIRST-CLASS MECHANICAL DESIGNER. Armstrong Siddeley Motors Limited requires a top-class Mechanical Designer, aged 26/32, for their Project Design Office. Applicants must be works trained designers with at least a Higher National Certificate and a sound background experience of aero-engine design. The position offered is for work on new designs for an engine of the future. This is an exceptional opportunity for a young engineer-designer to advance in the gas turbine industry.—Applications, with full details, quoting PD/MD2, in strict confidence, to the Chief Engineer, Armstrong Siddeley Motors Limited, Coventry. E9135 A

IMPERIAL CHEMICAL INDUSTRIES LIMITED

METALS DIVISION

A
RANGE OFFICER

is required for work at a static firing range in the Kidderminster area connected with a guided weapons project.

Candidates should possess the H.N.C. and/or A.M.I.Mech. Eng. and have completed an engineering apprenticeship or the equivalent. Some electrical knowledge would also be an advantage.

Excellent conditions of employment include pleasant rural surroundings, a generous starting salary with adequate scope for progressive remuneration, a contributory pension fund and a profit-sharing scheme.

Apply to General Services Manager, Imperial Chemical Industries, Limited, Summerfield Research Station, Kidderminster. E9433 A

IMPORTANT SOUTH LONDON ENGINEERING COMPANY requires ASSISTANT to WORKS MANAGER. Must have knowledge of all branches of light engineering, good designer with an innate ability to detect faults forthright, hard school personality preferred.—BOX No. E4415, "The Engineer." A

INDUSTRIAL ENGINEER required by firm of sophisticated industrial and operational research consultants in London. Degree good Mathematics, some knowledge of statistics and works experience essential, knowledge German useful.—Write for appointment, L. A. Ferney and Associates, 93, Westbourne Terrace, W.2. E4421 A

INSPECTION AND TEST ENGINEERS, to be based in London, required for inspection of plant and equipment, including Class I vessels. Good technical qualifications and apprenticeship or workshop training essential. Engineers with similar qualifications also required for site inspection, including extensive pipeline installations, on a site in the north of England. These appointments are with a well-known chemical manufacturing organisation and carry good salaries, commensurate with experience and qualifications. There is a pension fund, which includes Widows' and Children's Benefits. Write, giving details of age, qualifications, &c.—BOX No. E9406, "The Engineer." A

KUWAIT OIL COMPANY requires a TELECOMMUNICATIONS ENGINEER. Duties will involve engineering and planning of radio and telephone systems for installation in Kuwait. Good general standard of education, together with B.Sc. or H.N.C.; Corporate Member of I.E.E. preferred. Age approximately 30–35. Successful applicant will be required to serve up to one year in Kuwait before taking up duty in the company's London office. Salary according to qualifications and experience. Pension scheme.—Write for application form, giving brief details, and quoting L.O.239, to BOX W/172, c/o 191, Gresham House, E.C.2. E9422 A

JUNIOR DRAUGHTSMEN, having completed National Service, required for work on large chemical plant installations, A.E.S.D. minimum rates or above. Five-day week and superannuation scheme.—Apply by letter, giving details of technical education, to the Chief Draughtsman, Laporte Chemicals, Limited, Clifton House, Euston Road, London, N.W.1. E880 A

LEADING MANUFACTURERS of container closures in the Midlands have a number of vacancies for ambitious DESIGN DRAUGHTSMEN, preferably with some experience in this or a similar sphere. Interesting work with excellent salary and every opportunity for promotion to senior position in a rapidly growing organisation.—Write in confidence, with details of experience, positions held, salary required, to P.A. Metal Closures, Limited, Bromford Lane, West Bromwich. E832 A

MECHANICAL ENGINEER, under 30, required for South India by old-established British company with large engineering works. The duties are concerned with sales and engineering aspects of an interesting and wide range of plantation equipment. The initial tour would be on a salary commensurate with ability and experience, together with an annual bonus. Progression is entirely dependent upon merit. An outfit allowance is paid, and accommodation is provided by the company. There are frequent paid home and local leaves, and a pension scheme and Provident Fund.—Applicants, who should have completed a full apprenticeship and preferably be G.I.Mech.E., should apply to BOX No. E9416, "The Engineer." A

MECHANICAL ENGINEERING DRAUGHTSMEN required by John Smith's Tadcaster Brewery Co., Ltd., The Brewery, Tadcaster, Yorkshire. Age 25/35, of good general education and of H.N.C. or higher standard, and sound practical apprenticeship in a modern engineering works. At least two years' drawing-office experience essential, preferably on food, chemical or allied plant, pipework, pumps, vessels and steam utilisation. Applicants must be able to pass medical examination and be of active and energetic character. Good starting salary with annual increments if satisfactory, and prospects for a good man. Voluntary pension scheme in operation, canteen and sports facilities.—Reply to Chief Engineer, stating age and qualifications, education, apprenticeship, and positions held, in chronological order. Expenses will be paid to those selected for interview. E9392 A

MECHANICAL ENGINEERING ASSISTANT required by old-established company in the Central London area. Initially much of the work will be in the Chief Engineer's Drawing Office, but there will also be opportunities for experience in the supervision of site projects. Applicants should be between 25 and 30 years of age, have had general engineering training, and a technical education to at least Ordinary National, and preferably Higher National, standard. Experience of special purpose machine design, plant layout and installation o services, would be an advantage. Please reply.—BOX No. E4424, "The Engineer." A

METHODS ENGINEER required by manufacturers of a wide range of high-quality ground and milled threading tools. Previous experience on this type of work essential. Age 30–45. Applicants should give full details of training, experience and salary required.—BOX No. E9356, "The Engineer." A

NORTHERN ALUMINIUM COMPANY, LIMITED.—DRAUGHTSMEN required: (1) for General Engineering Department, at Rogerstone, Mon. Senior Mechanical and Structural Engineering Draughtsmen, to work on short and long-term construction plans for the company's existing works and for the development of new sites. The work covers civil engineering and building construction as well as the mechanical and electrical aspects of light alloy processing plant. Senior men are required who are sufficiently adaptable to take over the design aspects of defined sections of this work with the minimum of supervision. (2) For Sales Development Division, Banbury, Oxon. Senior and Junior Draughtsmen, to undertake design work in all fields of application to aluminium, including building, road transport, railways, shipbuilding and general engineering. Sound knowledge of structural design required. experience of aluminium not essential. Help with removal expenses.—Apply, giving brief details, to Northern Aluminium Co., Ltd., Bush House, Aldwych, London, W.C.2. E8963 A

PLANNING ENGINEER required for a modern foundry in Wiltshire. Applicants, who preferably should have had experience of general foundry and machine shop practice, must have experience of pressure die casting of aluminium. The post, which carries staff status and a good commencing salary, also affords very good opportunities to a man of drive and initiative. Please reply, giving full details. —BOX No. E9417, "The Engineer." A

PLANT ENGINEER required, to accept full responsibility for maintenance of varied and interesting production and service equipment.—Apply, stating previous experience, which is essential, age and salary, in confidence, to Crittall-Luxfer, Limited, Colwick, Nottingham. E4396 A

PLANT DEVELOPMENT ENGINEER, 28–
years of age, required for large, medium-
engineering factory situated near the centre
Birmingham. Applicants should hold an Engineer
Degree and/or be qualified for Corporate Mem
ship of the Institution of Mechanical Engine
Preference will be given to men with drawing-off
and workshop experience in the engineering indus
The position involves full responsibility to the Ch
Engineer for a heavy development programme
for the design, construction and setting to w
of a varied range of new special purpose pla
The Department is an expanding one and the posi
is suitable only for a man of outstanding ability
character. A salary commensurate with the respo
sibility will be paid and applicants should wri
giving particulars of qualifications, experience
present salary, to the Managing Director.—BOX N
E9353, "The Engineer."

PROJECT ENGINEER
Aveling-Barford, Ltd., invite applications for the position of Project Engineer, responsible to a director for co-ordinating design and development to ensure the introduction by planned date of new products in the earth-moving and allied fields. The position is one in which individual drive and initiative will be required in directing a project team drawn from technical and production departments. Essential basic qualifications are: a Degree or equivalent in Mechanical or Civil Engineering, experience in the design or development of mechanically propelled vehicles, and workshop experience. Minimum age 30. The salary envisaged is not less than £1000 per annum, dependent on experience and qualifications.
Please apply, giving full details of education, qualifications and experience, to THE SECRETARY, AVELING-BARFORD, LIMITED, Invicta Works, Grantham, Lincs. E9412 A

REQUIRED by Burmese Company for Lower Burma, qualified ELECTRICAL/MECHANICAL ENGINEER with experience of hydro-electric and centrifugal pumping plants and workshop practice. Single man preferred. Salary Kyats 22,000 (£1650) to Kyats 30,000 (£2250), dependent upon experience. Free housing and passage. Leave with full pay.—Applications, stating age and experience, with references and copies testimonials, to BOX No. DE/47, c/o 95, Bishopsgate E.C.2. E9364 A

SALES ENGINEER.—Anglo-American Company located London, and catering for the requirements of petroleum, power and process industries, solicit applications for situation as OUTSIDE REPRESENTATIVE. Good appearance, sales experience, and engineering background essential.—BOX No. E4414, "The Engineer." A

SENIOR DESIGN ENGINEER is required by Weston-Super-Mare by a well-known engineering organisation. The work is varied, but mainly mechanical engineering. Applicant should possess at least an Associate Membership of a Corporate Institute and/or an Honours Degree and have five years' minimum industrial experience. Salary will be high and in keeping with experience and qualifications. Please apply.—BOX No. E9316, "The Engineer." A

SENIOR DESIGN ENGINEER required by expanding firm of engineers of London in their hydraulic and mechanical press section in Dartford. Applicants should have a Mechanical Engineering Degree or equivalent and previous experience in this field would be an advantage, but any applicant with sound mechanical engineering experience will be considered. The successful applicant will be required to supervise the drawing-office development of standard machines and new prototypes and will be in charge of the purchasing of raw materials and components for the factory production of these presses. The position is a permanent one and has the prospect of promotion to executive status in the company. Five-day week and pension scheme. Apply, giving details of age, experience and salary required.—BOX No. E9424, "The Engineer." A

SENIOR DRAUGHTSMEN required by Manchester company accustomed to design of coal preparation plant. Pension scheme, canteen. State age, experience and salary required.—BOX No. E9225 "The Engineer." A

SENIOR DRAUGHTSMEN
with good hydraulic or mechanical experience are required by the Dowty Companies at Ashchurch, Glos., on a number of interesting industrial hydraulic projects. Pleasant area. Excellent working conditions with lodging allowance. Assistance with house purchase and removal expenses in approved cases. Attractive salaries for the right men.
Apply, giving full details, to Personnel Manager, Dowty Hydraulic Units, Ltd., Ashchurch, Glos. E8961 A

SENIOR MECHANICAL ENGINEERING DRAUGHTSMEN required for interesting work on large chemical plant installations. Experience in this type of work is desirable, but not essential; applicants with general mechanical engineering experience will be favourably considered. The post offer excellent opportunities with generous salaries commensurate with experience and ability. Offices situated in the N.W.1 London area. Five-day week and superannuation scheme.—Applications, which will be treated in confidence, should give previous experience and qualifications, and be addressed to the Chief Draughtsman, Laporte Chemicals, Limited, Clifton House, Euston Road, London, N.W.1. E9209A

TECHNICAL ASSISTANT wanted, preferably of H.N.C. standard, for experimental work on fuel injection and hydraulic control mechanisms. Free pension scheme, generous salary and pleasant working conditions.—Apply to Chief Personnel Officer, Bryce Berger, Limited, Ironbanks Works, Staines, Middx. E920 A

SITUATIONS VACANT

SENTINEL-RENAULT UNIT MACHINES

TECHNICAL SALES REPRESENTATIVES are required by Sentinel (Shrewsbury), Limited, to introduce Sentinel-Renault Unit Machines for Automation in the following areas :—

Northampton
Nottingham
Leeds
Glasgow

The position demands experienced men of proved engineering ability and carries an appropriate salary with pension rights. A car would be provided.

Applicants with necessary experience and qualifications are requested to apply to the Machine Tool Sales Manager, Sentinel (Shrewsbury), Limited, Shrewsbury (Tel., 2011), giving age and fullest details of education, training, experience and positions held, with dates in chronological order. E9420 A

SITUATIONS VACANT

SMALL GEARS

DESIGNER required by large engineering concern in the Midlands.

His main preoccupation will be the design of small geared mechanisms, produced in very large quantities.

Age will be of secondary importance, but the successful applicants must have practical experience in mechanical engineering with a gearing bias ; some electrical experience will be a decided advantage.

This will be an important appointment, for which a commencing salary of four figures will be paid.

The company provides excellent working conditions ; very generous life assurance provisions ; a contributory pension scheme with benefits above the average ; wide choice of recreation and sports facilities.

Please send your reply, giving full particulars of your age, education and experience, to E227, Personnel Executive.—BOX No. E9436, "The Engineer." A

SITUATIONS VACANT

SENIOR TECHNICAL ASSISTANT required by Marine Engineering Works on Clyde. Graduate having turbine experience preferred. Apply, giving details of experience, &c.—BOX No. E4423, "The Engineer." A

TECHNICAL REPRESENTATIVES required by old-established Engineering Company. Applicants must have proved connections with engineering firms, basic and chemical industries, power stations, &c., and conversant with their requirements. Vacancies : Newcastle, Leeds, Manchester, Birmingham, Cardiff. Apply in strict confidence.—BOX No. E4425, "The Engineer." A

THE BRITISH ERMETO CORPORATION, LTD., require one or two young TECHNICAL ASSISTANTS to train as Junior Executives. Applicants must have had shop and drawing-office experience and a good technical education. The Corporation operates a contributory pension scheme with life insurance cover. Salary will depend on past experience and special qualifications for this appointment.—Apply in writing, giving age and brief particulars of experience, to British Ermeto Corporation, Ltd., Beacon Works, Hargrave Road, Maidenhead, Berks. E9437 A

TIME STUDY ENGINEER required, with good all-round experience. Perference will be given to a consultant trained man with knowledge of metal working or chemical processes. Good conditions and prospects in expanding company. Write, giving full details, salary required.—BOX No. E4409, "The Engineer." A

TWO DRAUGHTSMEN with experience of jig and tool design on batch and line production methods required. These are interesting and progressive appointments, offering wide scope for design initiative under excellent working conditions. The salary offered is from £767 to £850, depending upon qualifications and experience. The company operates a generous pension scheme and has comprehensive welfare and sports club facilities.—Apply to Chief Personnel Officer, Petters, Limited, Causeway Works, Staines, Middlesex. E909 A

WEAVING FOREMAN required by international organisation, for department producing high-quality precious metal gauze. The position offers scope for development and a substantial salary will be paid.—Please write fully, Personnel Officer, Baker Platinum Division, Engelhard Industries, Ltd., 154/170, Vauxhall Street, S.E.11. E4408 A

WORKS ENGINEER.—Wanted for modern chemical processing factory in East London. Experience in mechanical and electrical plant essential. Full details.—BOX No. E9430, "The Engineer." A

WORKS MANAGER AND PRODUCTION ENGINEER required for machine and fitting shop for process equipment at Dartford. H.N.C. or better. Able install costing and planning. Initiative essential. Good prospects for keen and efficient organiser. State age, experience, salary, &c.—BOX No. E9425, "The Engineer." A

WORKS SUPERINTENDENT required by manufacturers of wide range of high-quality ground and milled threading tools, employing approximately 150. Previous experience in control of the production of tools for sale essential. Age preferably 35–45 years. Applicants should give full details of training, experience and salary required.—BOX No. E9355, "The Engineer." A

SITUATIONS VACANT

A. V. ROE & COMPANY LTD.

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SENIOR AIRCRAFT STRESSMEN

These positions offer the opportunity of working on Britain's most advanced Supersonic Aircraft.

Candidates should possess a senior Mechanical or Aeronautical Engineering Degree or equivalent, and not less than three years' previous experience.

Individual salaries will be arranged in accordance with the qualifications of the applicant.

Apply, quoting full particulars and Ref. A/C/R/ 157/S.S/IE, to :

The Chief Designer,
A. V. Roe & Co. Ltd.,
Greengate,
Middleton,
Manchester.

E9399 A

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WILTON WORKS

over £12,000,000 a year are being spent on the construction of the largest single project in Britain's chemical history, which includes an up-to-date power station using high pressure and high temperature steam. Wilton Works is a manufacturing centre, where any Division of I.C.I. can build and operate production units. Such well-known products as "Perspex," "Terylene" and Titanium are produced here. Building has proceeded continuously since 1946 and the factory now covers 400 of the 2000 acres allocated for development. The number of Engineers required for its design, construction and operation is steadily increasing.

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After joining, married men will receive a reasonable refund of removal and travel expenses, and to assist them in house purchase, facilities are available in approved cases for loans and advances of legal charges.

Wilton is situated at the foot of the Cleveland Hills, between Middlesbrough and the coast, and is clear of the industrial smoke belt. Working conditions and recreational facilities are first class.

If you are interested in a satisfying career, working with men of high calibre, please write to me : Staff Manager, Imperial Chemical Industries, Ltd., Wilton Works, Middlesbrough, Yorkshire, quoting 352/4. E9358 A

Classified Advts. continued on page 6

SITUATIONS VACANT

AUTOMOTIVE PRODUCTS COMPANY LIMITED. LEAMINGTON SPA.

BORG & BECK DIVISION

Applications are invited from suitably qualified DESIGN DRAUGHTSMEN for interesting Development Work in connection with Clutches and Automobile Transmission Systems.

A sound engineering background to H.N.C. standard is essential and design experience in the automotive field is desirable.

This Company, which manufactures vehicle components of international repute, offers outstanding opportunities in the Design and allied fields. Salary, including participation in a generous profit-sharing scheme, will be commensurate with experience and qualifications.

Full particulars should be sent in strictest confidence to the Personnel Officer :

AUTOMOTIVE PRODUCTS COMPANY, LIMITED,
TACHBROOK ROAD,
LEAMINGTON SPA,
WARWICKSHIRE.

E9402 A

SITUATIONS VACANT

MANAGEMENT TRAINEES

Large expanding light engineering Company in the South Midlands is prepared to engage a selected number of Young Men (23–30) for training through technical work, foremanship and on eventually to Managerial Posts. Qualifications required :

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3. Five-year apprenticeship in reputable engineering firm or equivalent experience.

Applicants must be prepared for factory hours during training (including nightshift if necessary) and to work hard for a number of years to fit themselves for the higher posts in engineering industry. Apply in own writing, giving age, qualifications, present salary and career to date, in chronological order.

BOX No. E9294, " The Engineer. A

SITUATIONS VACANT

ASSISTANT TO DEVELOPMENT ENGINEER

Assistant to Development Engineer required, minimum qualification H.N.C. (Engineering). Metallurgical laboratory experience essential.

Contributory pension, life assurance, and profit-sharing bonus schemes apply.

Housing accommodation if required.

Write, stating age, past experience, and salary level, quoting S.A.L.1, to :

The Personnel Officer,
Foster Yates and Thom, Ltd.,
Heavy Precision Engineers,
Blackburn. E9284 A

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SENIOR APPOINTMENTS must be made for important work on a number of mechanical problems, including high-performance gearing, stress and vibration measurement, rotating seals, gas dynamics and instrumentation, bearings of all kinds for a wide variety of applications, including gas lubrication, operation at high temperatures and the uses of new materials and lubricants.

Our need is such that we will give outstanding opportunities and rewards to anyone who can contribute to solutions of these problems. Professional qualifications and some experience of similar work are desirable.

Please reply to Dept. C.P.S., 336/7, Strand, W.C.2, quoting ref. E795A.

E9398 A

LOCKHEED HYDRAULIC BRAKE COMPANY LIMITED, LEAMINGTON SPA.

Specialists in the field of Automobile and Aircraft components, invite applications from young men who have recently completed, or are about to complete, their Engineering Apprenticeship or Drawing Office Training, for posts as :—

JUNIOR DRAUGHTSMEN

in their Design Drawing Offices.

These positions offer excellent opportunities to men seeking further Drawing Office experience in preparation for careers in Design or Production Engineering.

Minimum qualifications O.N.C.

Good salaries are offered plus Profit Sharing and Pension Schemes. Five-day week.

Applications to Employment Officer, Lockheed Hydraulic Brake Co., Ltd., Tachbrook Road, Leamington Spa. E9403 A

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Have the following vacancies:—

ENGINEERS :

Mechanical—with at least 5 years' practical experience, preferably in design and/or testing of Indicating Instruments or associated equipment. H.N.C., but preferably A.M.I. Mech. E.

Electrical—with at least 3 years' practical experience, preferably in testing Electrical Instruments and/or Electro-magnetic mechanisms. H.N.C. preferably Grad. I.E.E.

DEVELOPMENT ENGINEER : with practical drawing-office and design experience, for development of small mechanical or electro-mechanical mechanisms. H.N.C., but preferably A.M.I. Mech. E.

PROCESS PLANNING ENGINEER: with experience of instrument manufacture. Able to layout machine processes from drawings. H.N.C. standard or equivalent in workshop practice.

SUPERVISION ENGINEERS: to supervise production of instruments to specification. O.N.C. standard in Electrical or Mechanical Engineering.

SENIOR DESIGN DRAUGHTSMAN : with experience of instruments or light engineering. Minimum qualifications, 3 years' design experience ; O.N.C. standard. Monthly status for right man. Older man with good press tool experience considered.

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ESTIMATOR : with practical background and knowledge of production operations and work study. O.N.C. standard.

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All these positions are progressive and only those able to command good salaries should apply to :

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GLA 3333

E9401 A

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preferably possessing Higher National Certificate, or its equivalent, conversant with the design of modern works, and having experience in the following branches of Engineering

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STRUCTURAL

are urgently required to fill immediate vacancies in the Design Office, working on the further development of this, the newest addition to Britain's Chemical Industry. Suitable candidates in these categories will be invited for interview without commitment, at the company's expense.

SECURITY : The appointments are permanent and carry with them that high degree of security which the Company offers.

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HOUSING : Assistance is given in the procuring of rented houses, flats or lodgings. Married men will receive a reasonable refund of removal (including travel) expenses, and to assist them in house purchase, facilities are available in approved cases for substantial loans. In addition, legal charges will be advanced.

Wilton is situated at the foot of the Cleveland Hills in Yorkshire, five miles from the coast and clear of the industrial smoke belt. Working conditions and recreational facilities, including football, cricket, tennis, golf, badminton, and archery, are first-class. If you want an interesting and rewarding job helping to design the British Chemical Industry of the future, please write to me :—The Staff Manager, Imperial Chemical Industries Limited, Wilton Works, Middlesbrough, Yorkshire, quoting 360/4. E9357 A

SITUATIONS VACANT

JUNIOR CIVIL ENGINEERS

required by Associate Company of

RICHARD COSTAIN LTD.

for work in

NIGERIA

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H.P. motor 12.

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Separate M.D. to each head. 4 tables.
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Phone : RELiance 7201 *Grams :* Sotoolsag London S.E.11. E212 G

Classified Advts. continued on page 8

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GILLY

TABLE TYPE

HORIZONTAL BORERS

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2¾in. diameter Spindle, 20in. facing cap.

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3¾in. diameter Spindle, 30in. facing cap.

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E211 G

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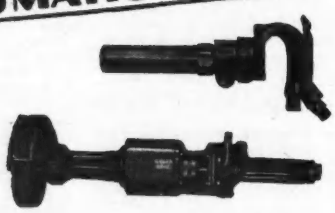

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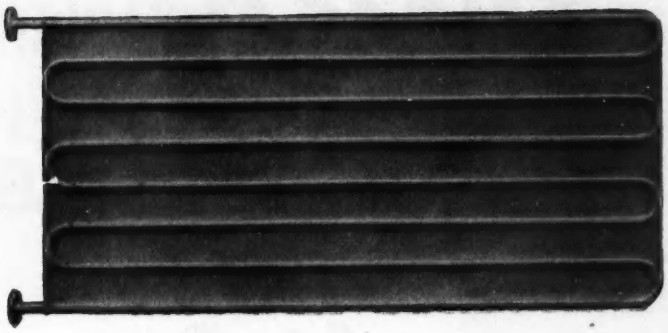

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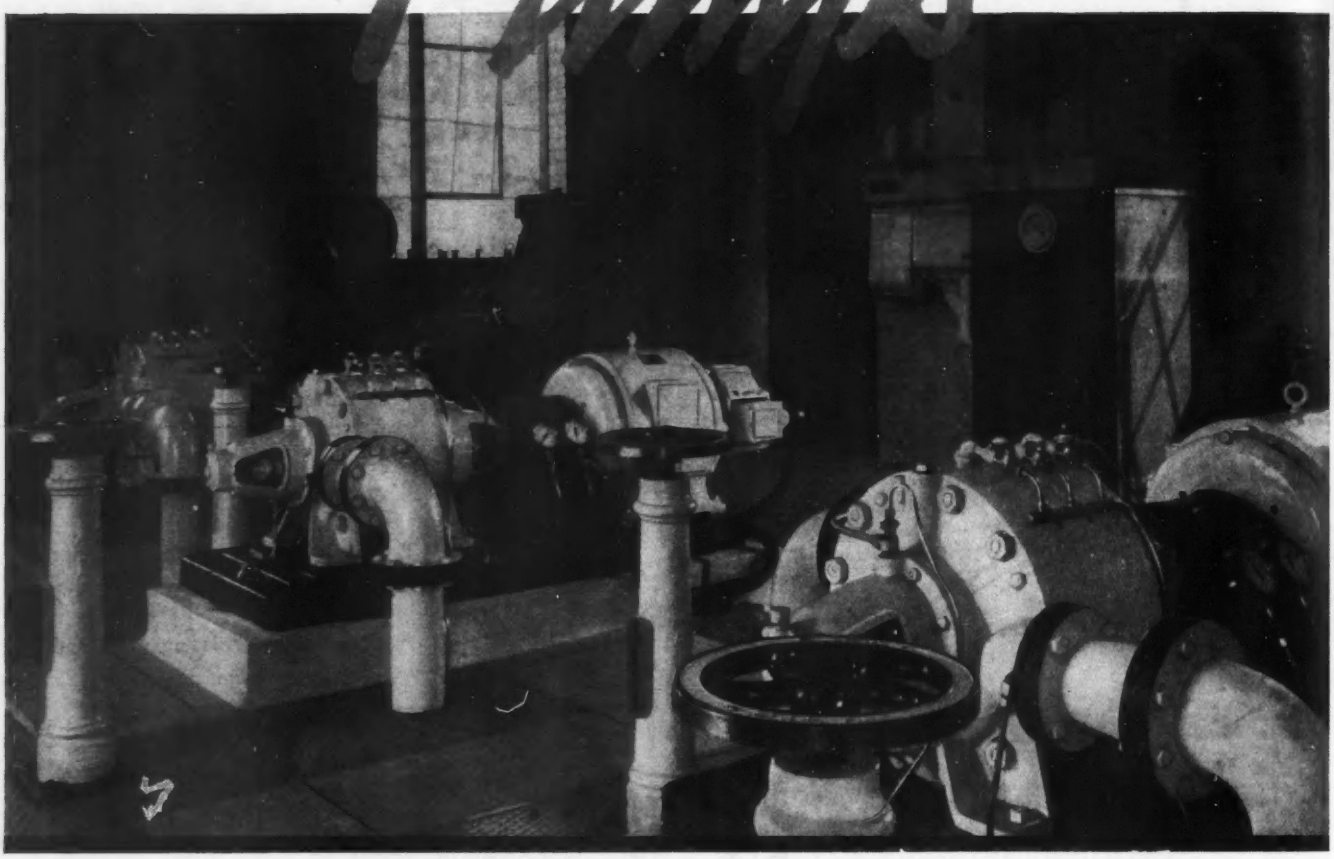

The pumping machinery in the above photograph was supplied by Gwynnes Pumps Ltd to the instruction of Horace Rippin, Esq., A.M.I.C.E., A.M.I.Mech.E., A.M.I.W.E., Engineer and Manager to the East Elloe Rural District Council. The plant comprises two electrically operated automatic booster pumps and also one diesel engine driven booster pump. Each pump delivers 417 G.P.M. against a head of 200 ft.

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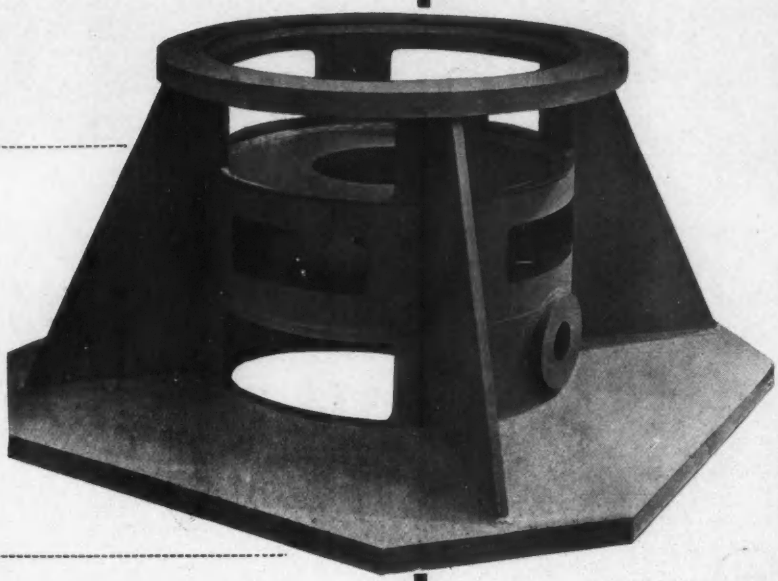
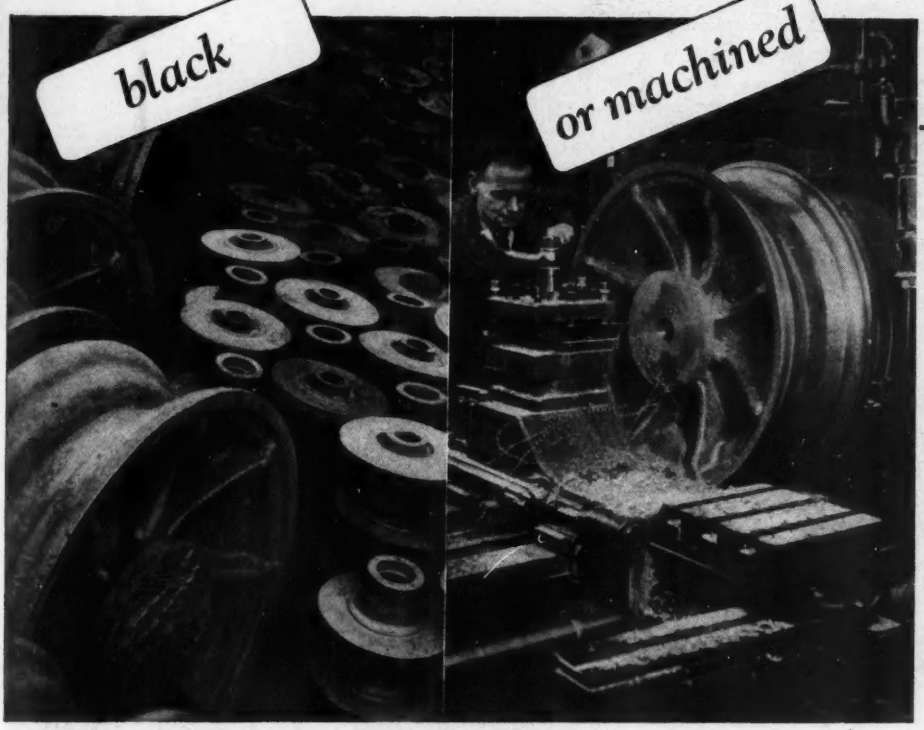


A Fabricated Mild Steel Vertical Thrust Housing with Oiltight Chamber. Machining allowance of ¼" on all finished surfaces.

Photograph by courtesy of Michell Bearings Ltd., Newcastle-upon-Tyne.



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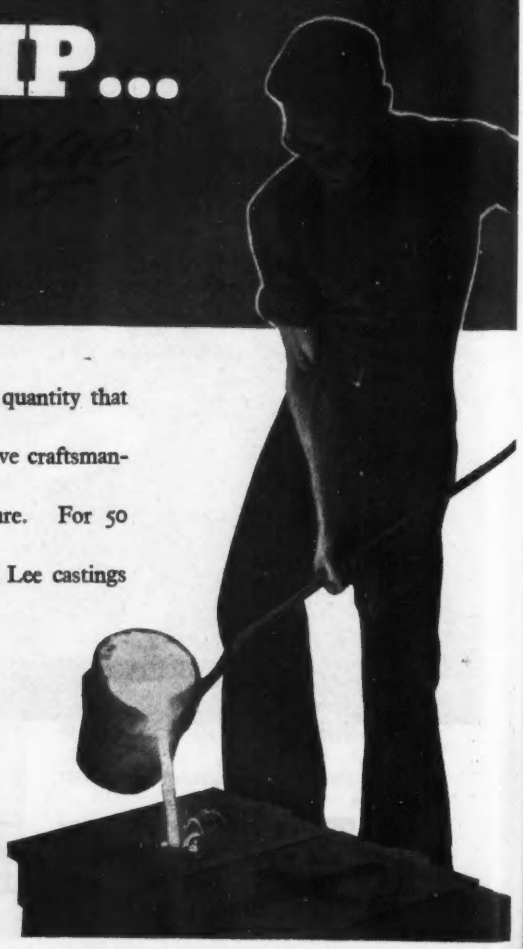

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Outstanding reliability, low installation costs, low running costs and easy operation . . . these are the qualities that make Brush Radial-Flow Turbines standard power station equipment throughout the world . . . the reason why every year Brush turbines are providing cheap abundant power for industry, for agriculture and for the needs of the people. Brush turbines cut capital outlay . . . they do not need massive foundations and can be housed in relatively small buildings. Added to this they are easy to operate and running costs and maintenance costs are less with Brush Turbines. They can be run up from cold and put on load in a few minutes—even when operating at the highest steam temperatures—and there are no delays when the turbines are still warm following shutdown, they can be restarted at any time and be back on load within minutes. Engineers who specify Brush turbines can expect quick delivery . . . whether it's a 2 or a 30 megawatt set, or any of the intermediate sizes, Brush gives guaranteed delivery dates. Brush Radial-Flow Turbines embodying the Ljungström principle typify the Brush approach to power problems—sound basic ideas proved by ceaseless research and development and backed by the enormous manufacturing resources of the Brush Group. That's why power engineers the world over know that they can stake their reputation on Brush generating and power distribution equipment.

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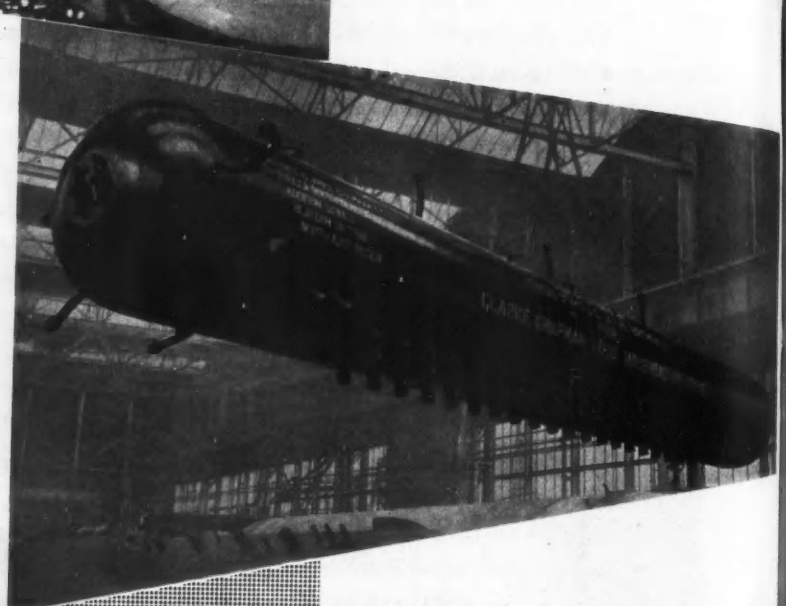

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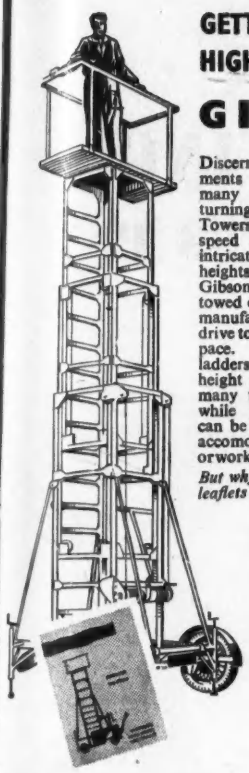

GETTING DOWN TO IT IN HIGH PLACES WITH . . .

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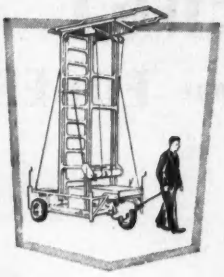

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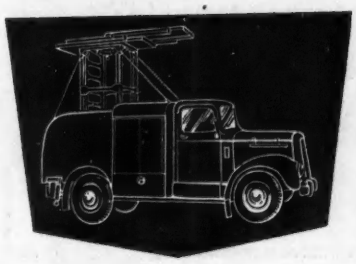

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This new range of Aeroflex Fuses (AD and FC type) Category 440 AC5 Class P - is fully interchangeable with the former patterns and is now supplied in all listed Fluvent Switch and Fusegear. They offer refinements in performance, primarily due to the following factors:-

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Publication CF2 deals extensively with the subject and affords interesting data. A copy will be forwarded gladly to enquirers and students.

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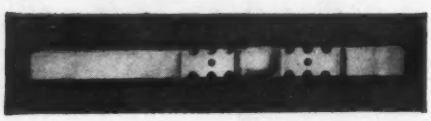
(4) The cartridge cases are ceramic instead of fibre.

(5) The end caps are fixed instead of being detachable as in the AF pattern, and re-wiring is normally carried out by returning blown cartridge fuse-links to the factory and not on site.



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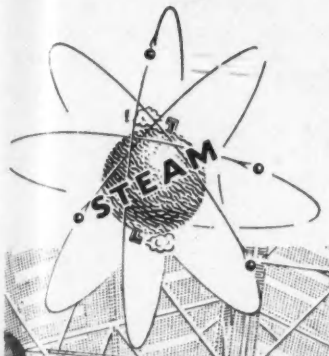

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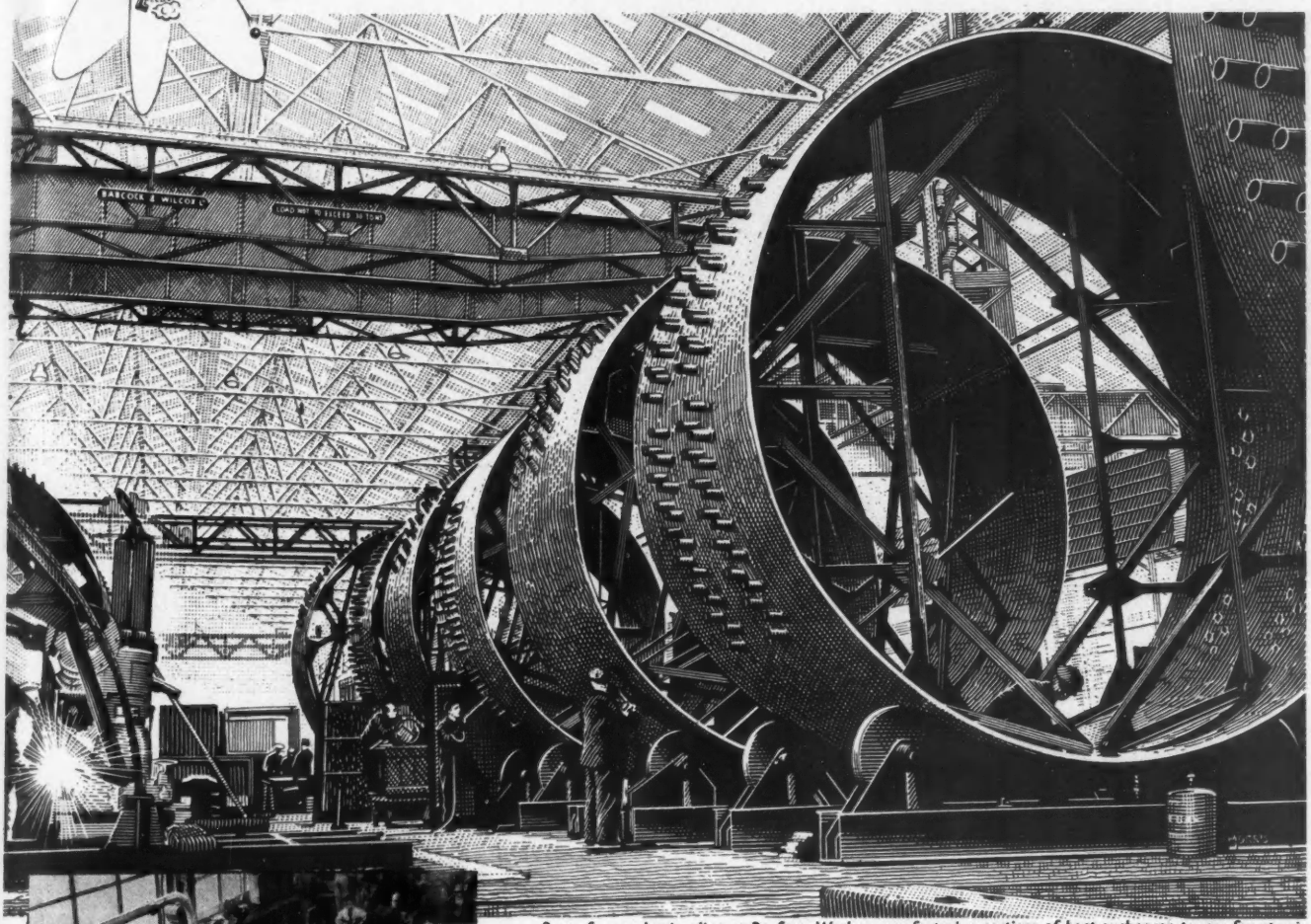
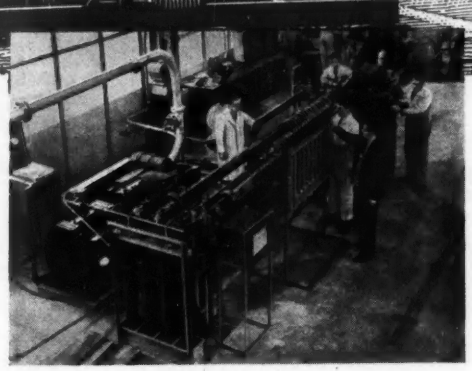


Part of a production line at Renfrew Works, manufacturing sections of heat-exchanger towers for atomic power stations.



Test-rig for reactor fuel cans under full-scale gas pressure and mass-flow conditions.

Equipped for the job

Babcock progress in nuclear power engineering is based on a balanced approach to the problems of both *heat exchanger* and *reactor* design and construction.

The company has already manufactured the sixteen 80 ft. high *heat exchangers* for Calder Hall A and B nuclear power stations and is well advanced with another sixteen for Chapel Cross.

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In both these aspects of manufacture the company has an unsurpassed experience of the problems involved, and is bringing to bear well-proved research and manufacturing techniques, which it had already developed for use in parallel fields. At its Renfrew Works it has laid down complete production lines for the manufacture of nuclear power plant.

It has an intensive research programme relating, for example, to the design, construction and performance of reactor pressure vessels, fuel elements and cans, and to further developments in methods of heat exchange.

It has extended and re-equipped its Renfrew Works and Research Station at a cost of some £7,000,000 over the past 10 years; and much of this development is related to nuclear power requirements.

It has brought together in its Atomic Energy Department a trained and experienced personnel.

Babcock & Wilcox Ltd. is moving fast in the field of nuclear power engineering because it is *equipped for the job.*

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For the design and building of complete atomic power stations of the gas-cooled, graphite-moderated type, Babcock & Wilcox Ltd. are in association with English Electric Company Ltd. and Taylor Woodrow Ltd. bringing to such undertakings an outstanding combination of facilities and experience in mechanical, electrical and civil engineering.

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B

Colombo Port Development

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Consulting Engineers: Messrs. Coode & Partners.

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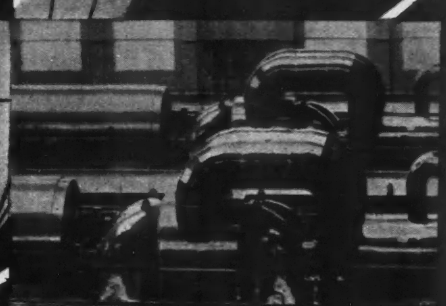

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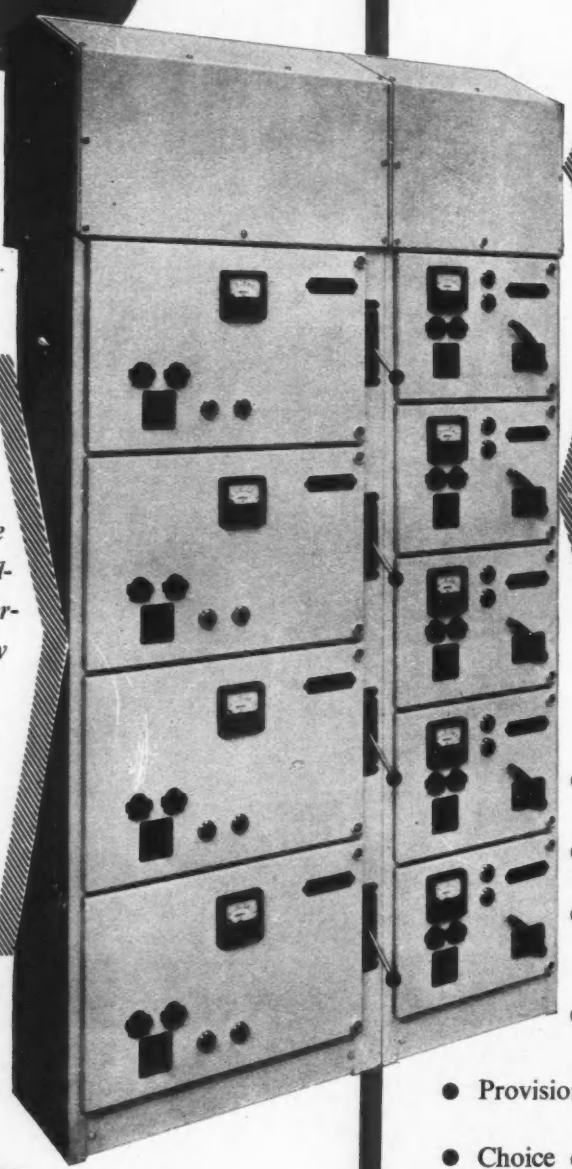

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Chamber for main horizontal busbars and outgoing terminal blocks, each with separate detachable cover.

FIVE-TIER TYPE GAO 30

The type GAO 30 five-tier unit has triple pole 30-amp isolating switch at right, interlocked mechanically with door.

Ammeter, push buttons, rotary switch and indicating lamps mounted on door.

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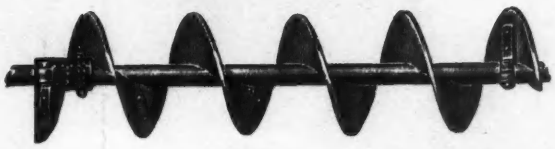

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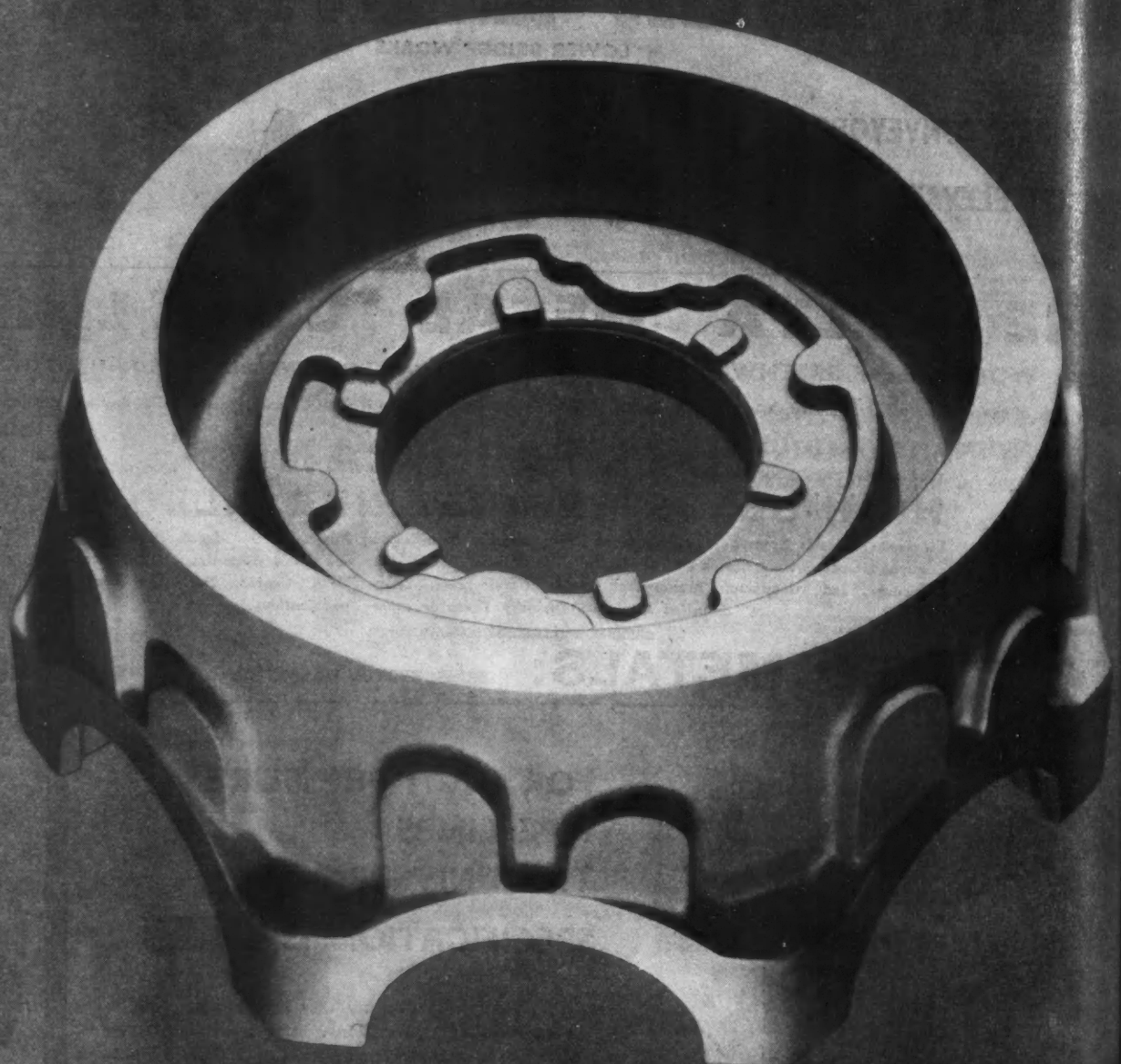

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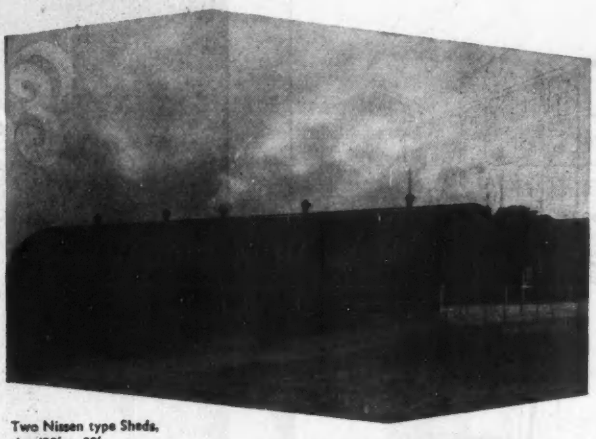

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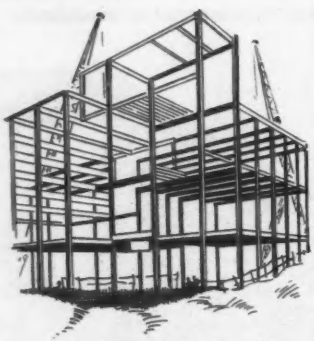

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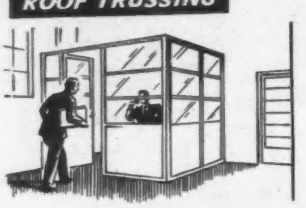

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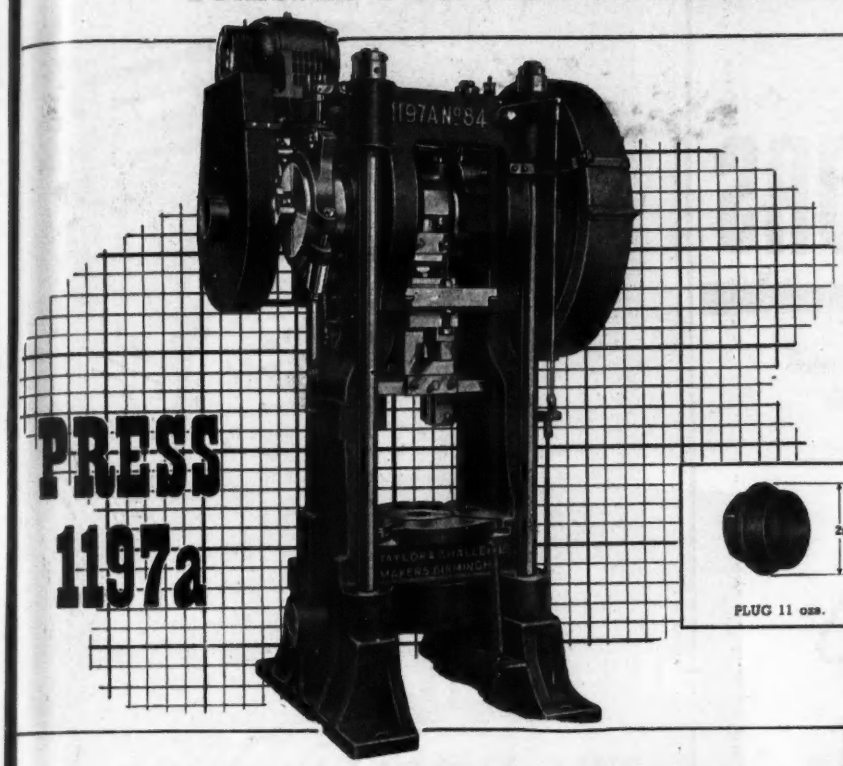
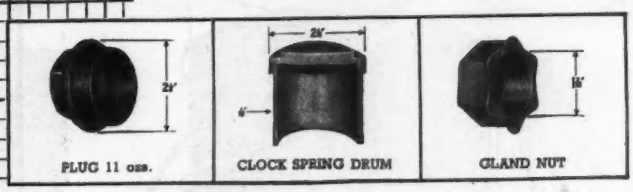


PRESS 1197a

These presses have the rigidity, speed and accuracy essential for hot forging, with a uniform finish, brass and other non-ferrous alloys. Press 1197A gives a pressure of 100 tons, and the examples illustrated are typical brass forgings which it makes in closed dies. We make similar presses for this work up to 500 tons capacity.



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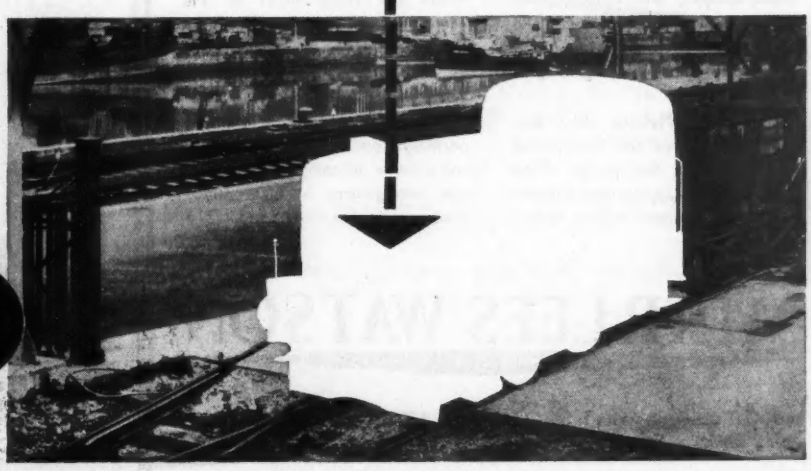
This Peckett Diesel supplied to Albright & Wilson Ltd. is of standard design.



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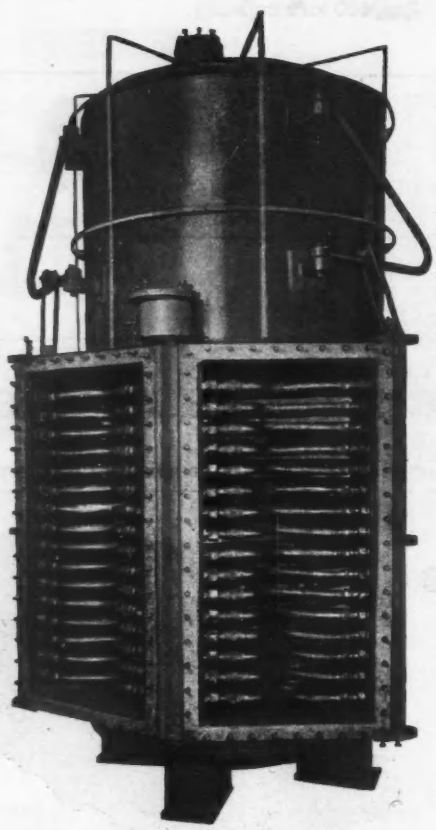

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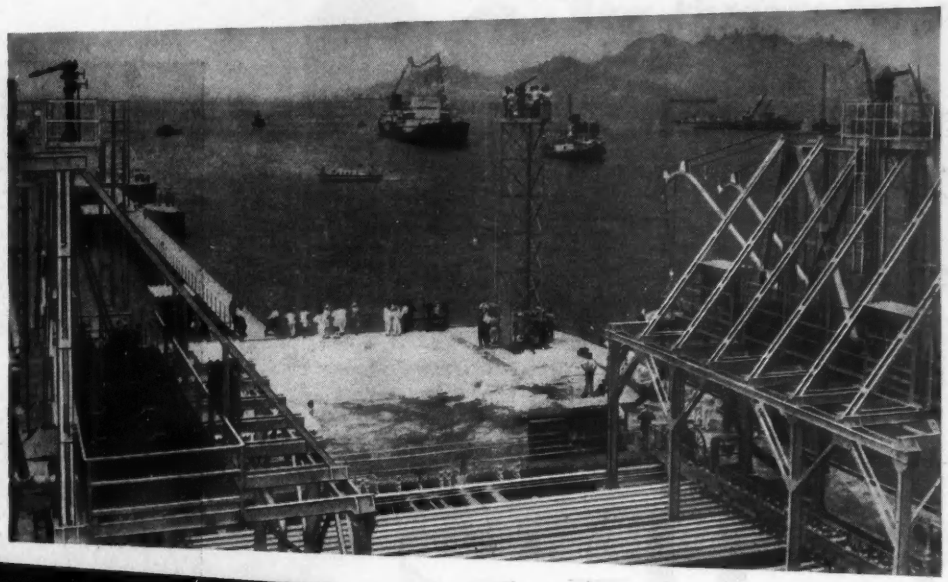
Below right : Kent Oil Refinery, Isle of Grain.

Bottom : Kwinana Refinery, Australia.



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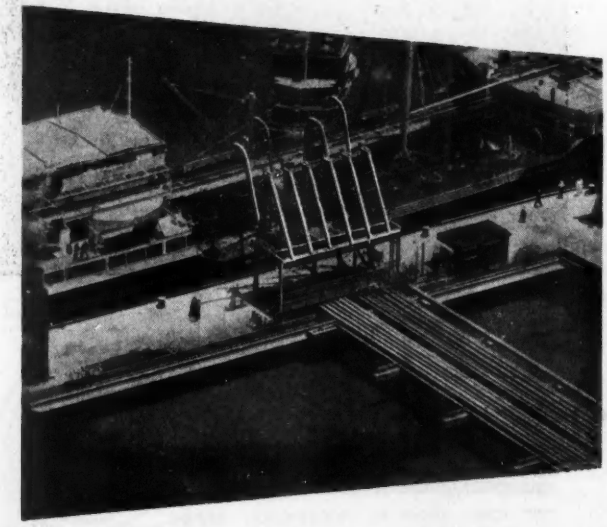

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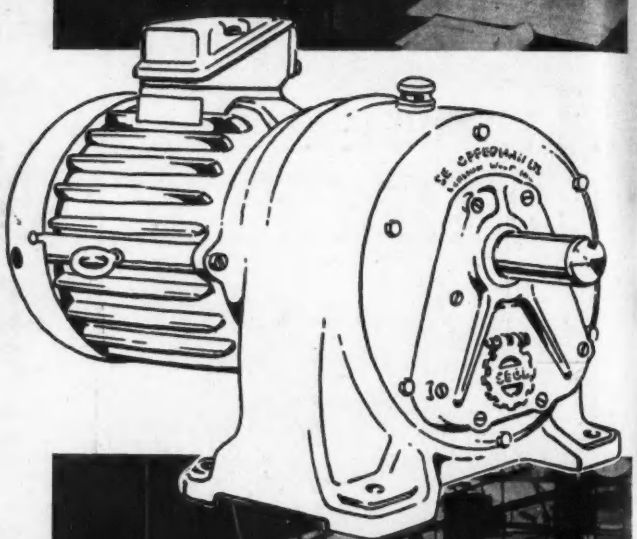

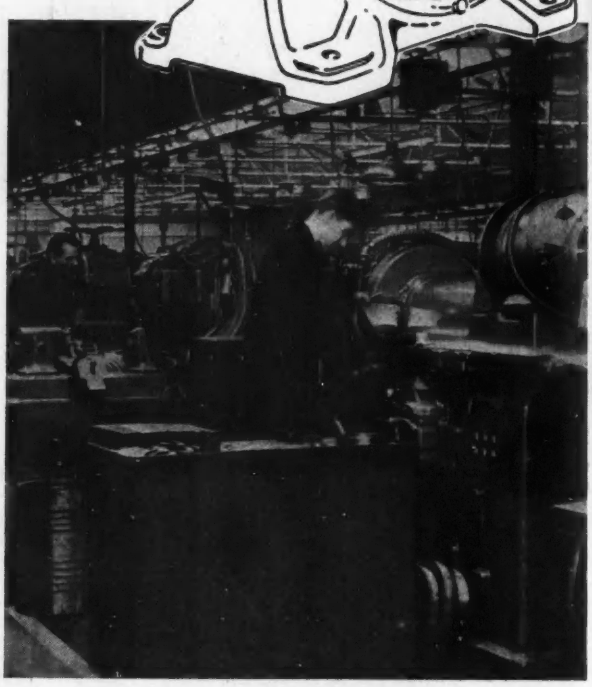

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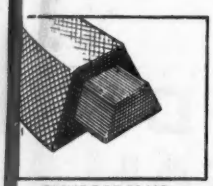

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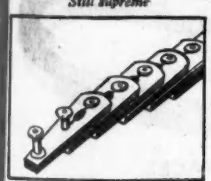

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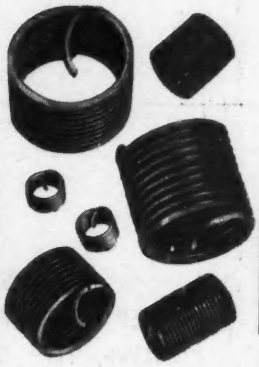

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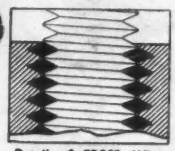

Detail of CROSS Wire Thread Insert in position

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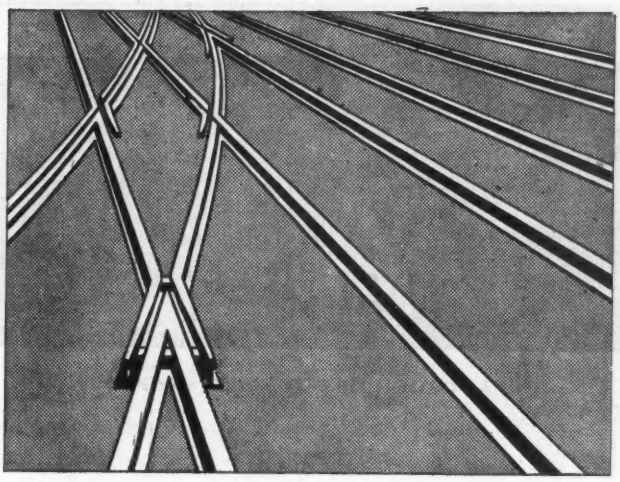

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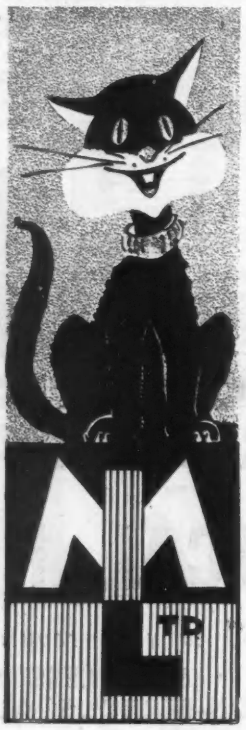

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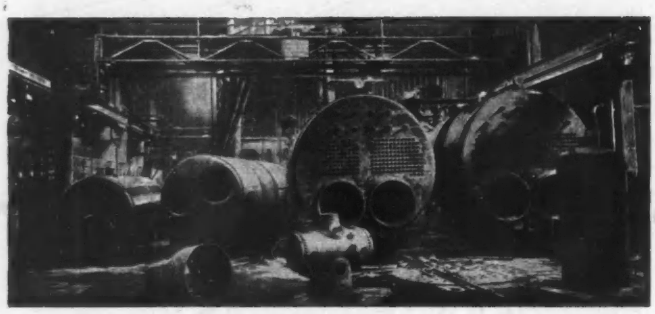

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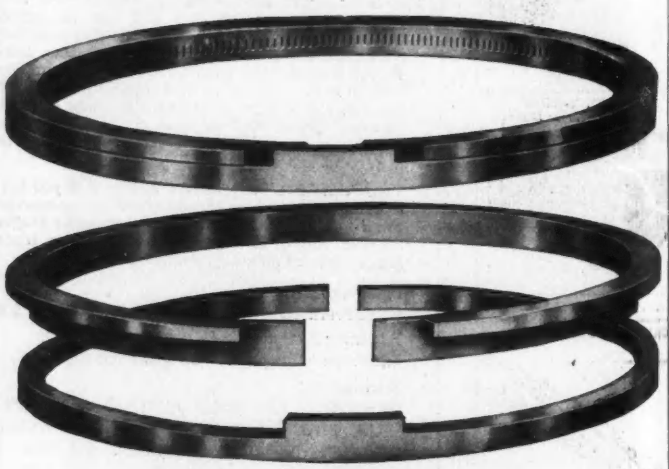

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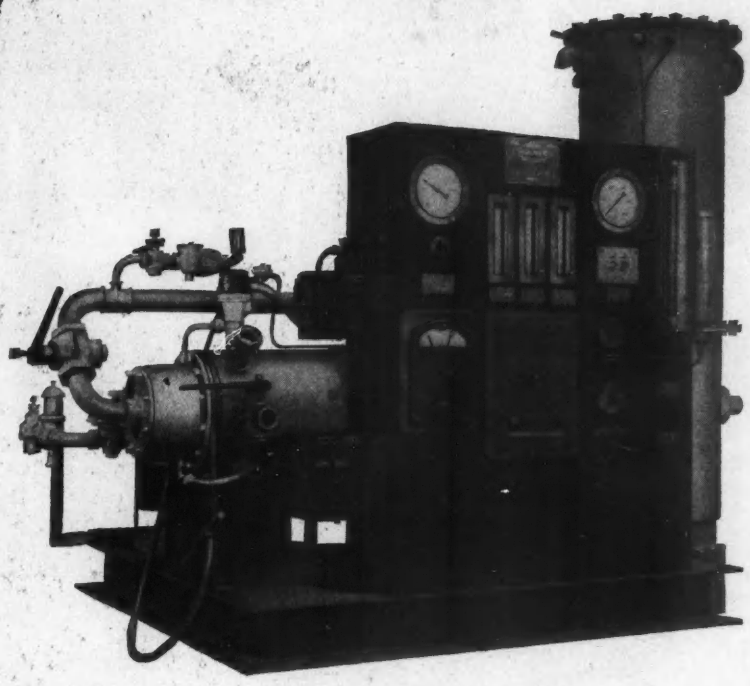

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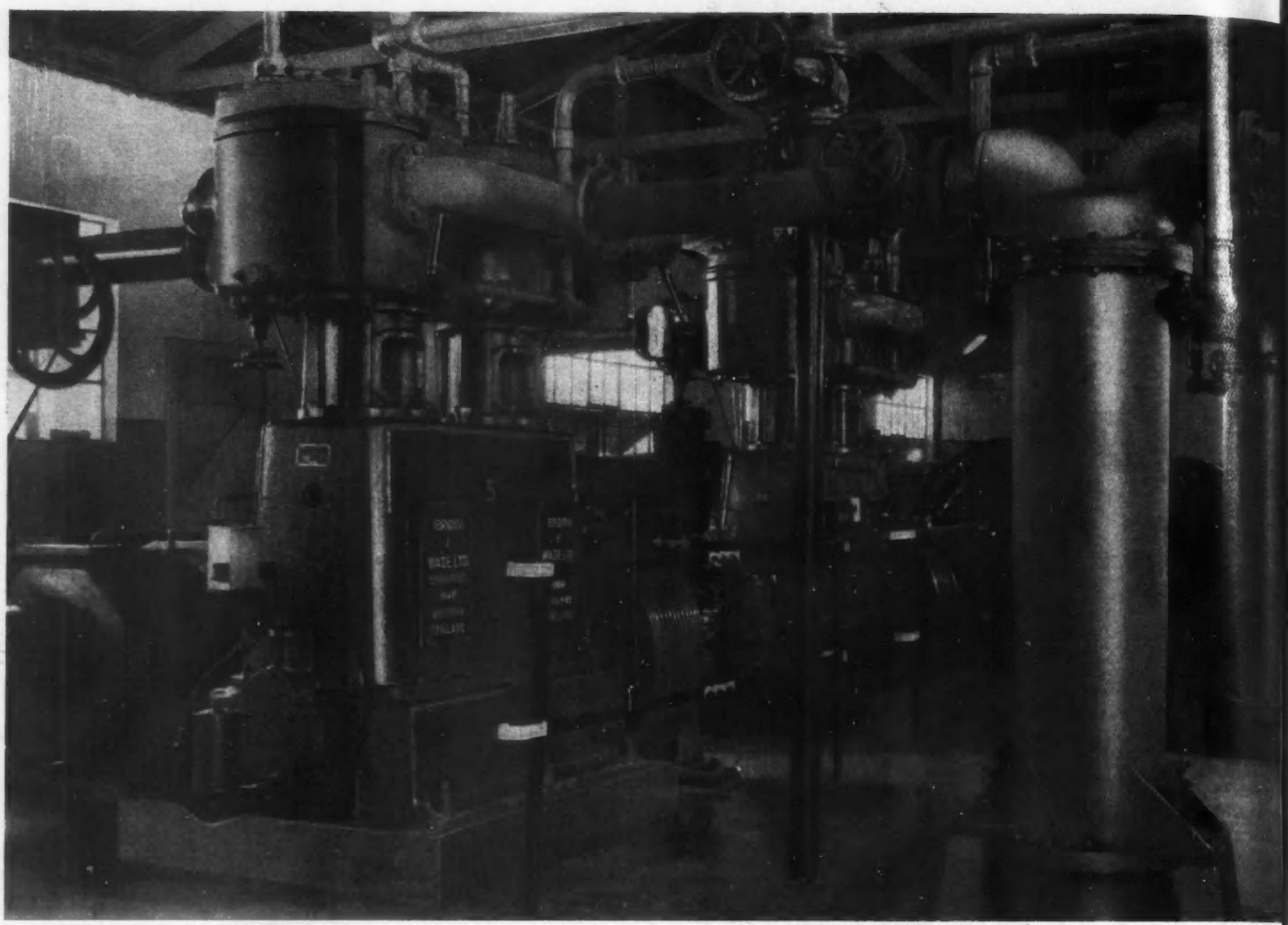

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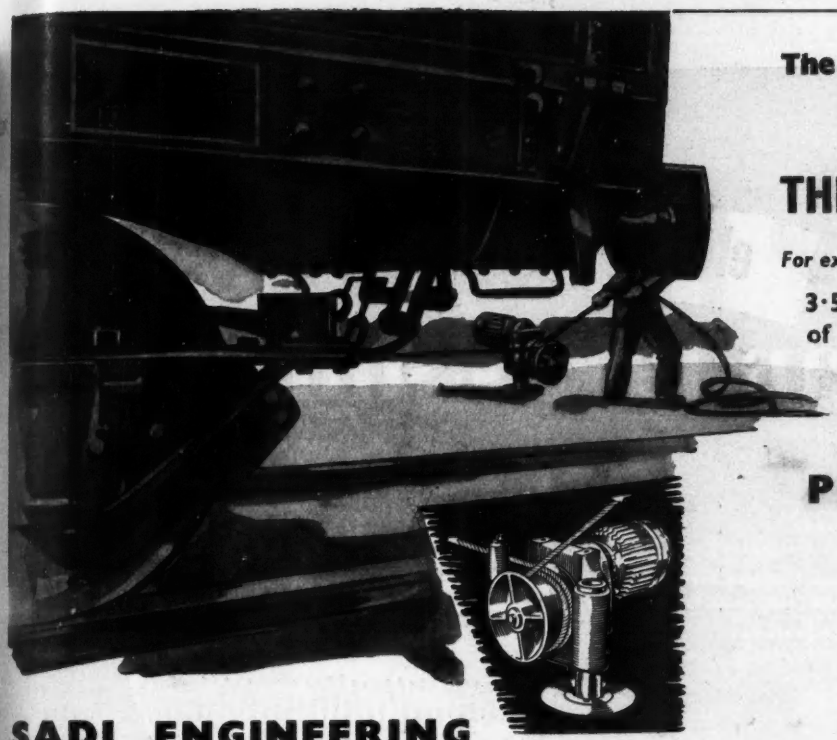

Capstan in operating position. Note horizontal pulley and automatic swivelling action.

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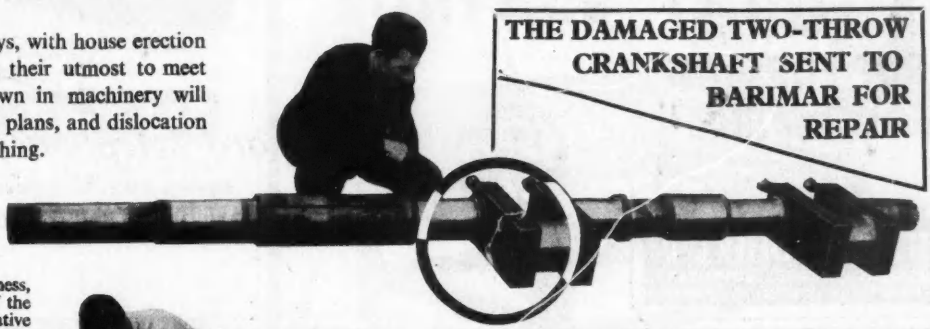

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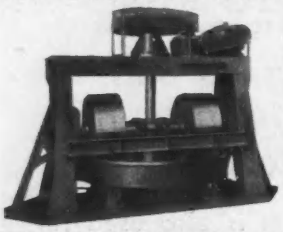

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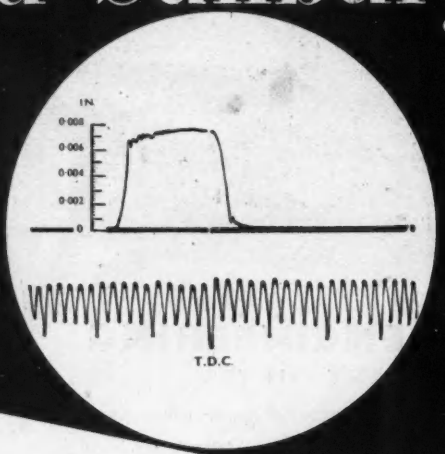

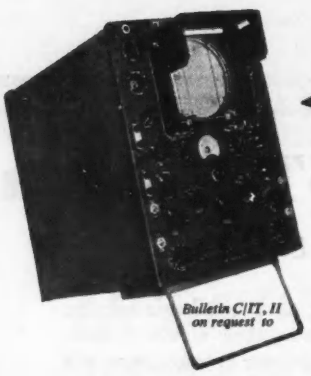

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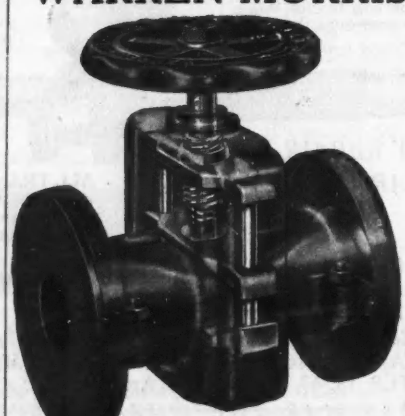

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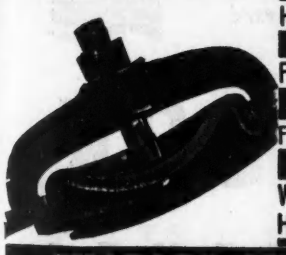

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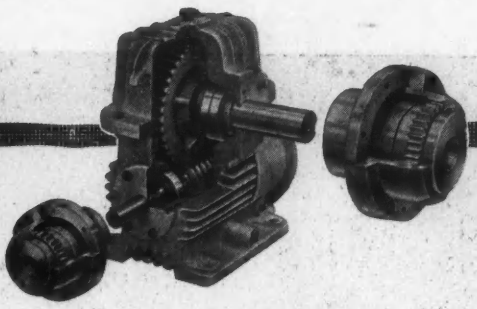

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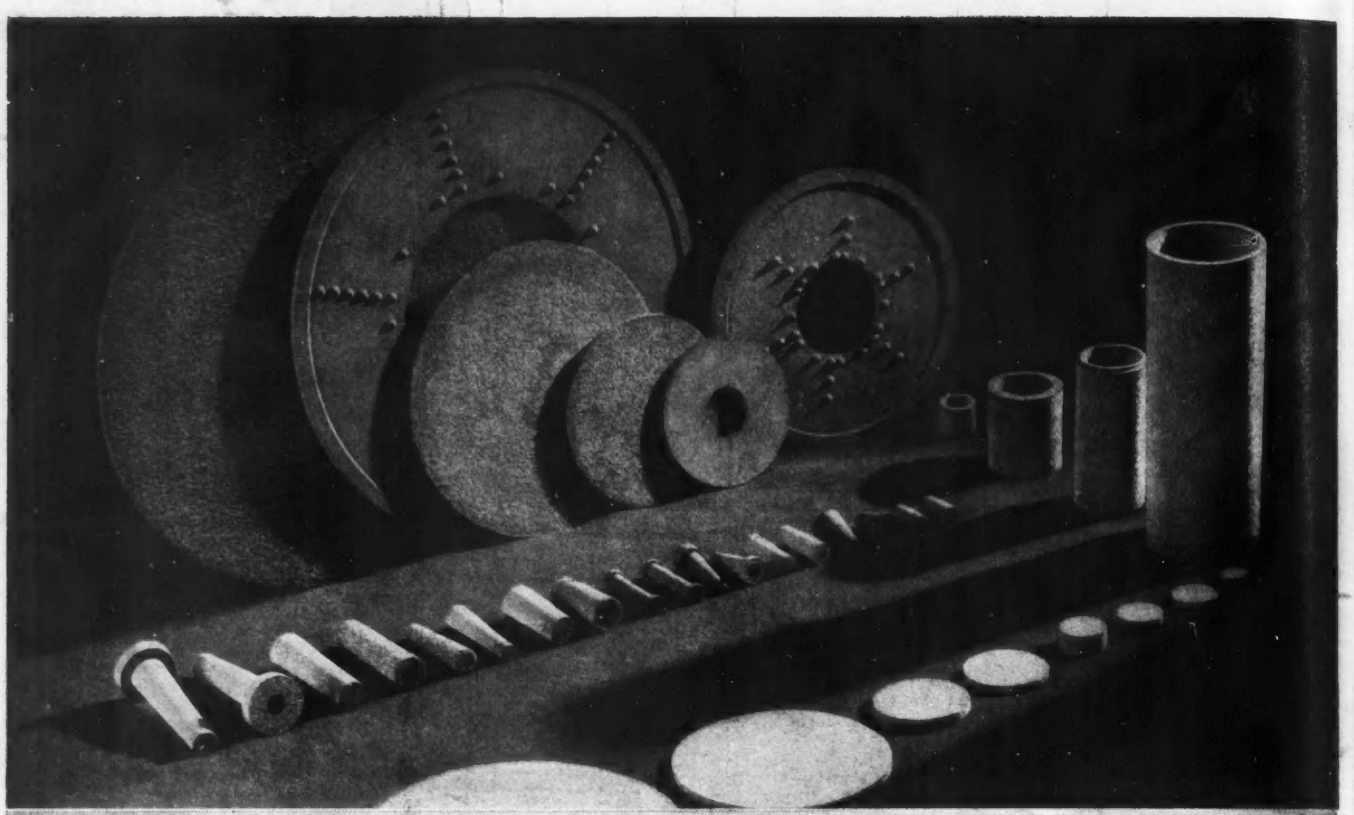

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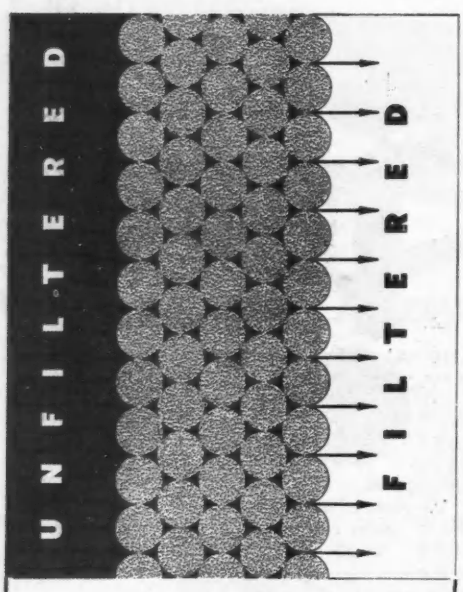

This enlarged diagram shows the pores which exist between the spherical particles of metal. It is through these interstices that the liquid or gas is filtered under pressure.

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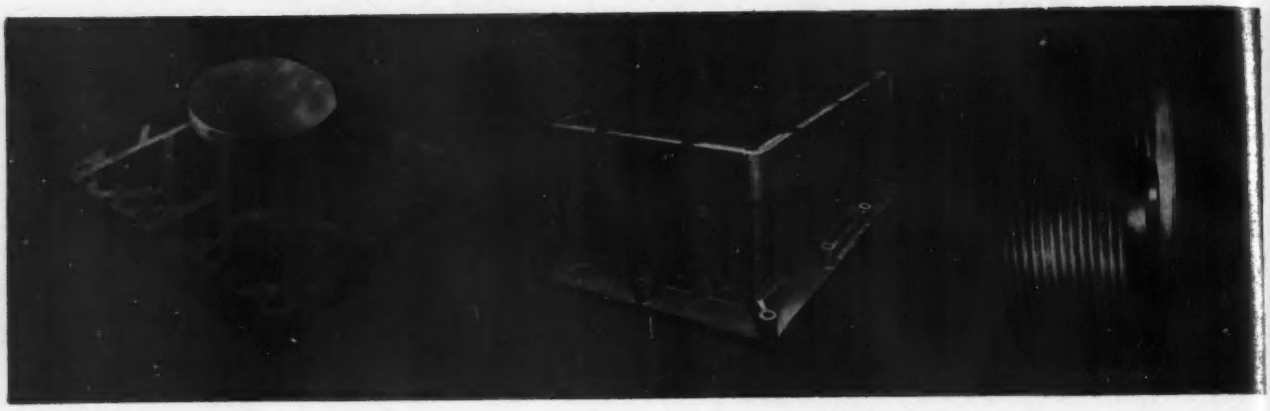
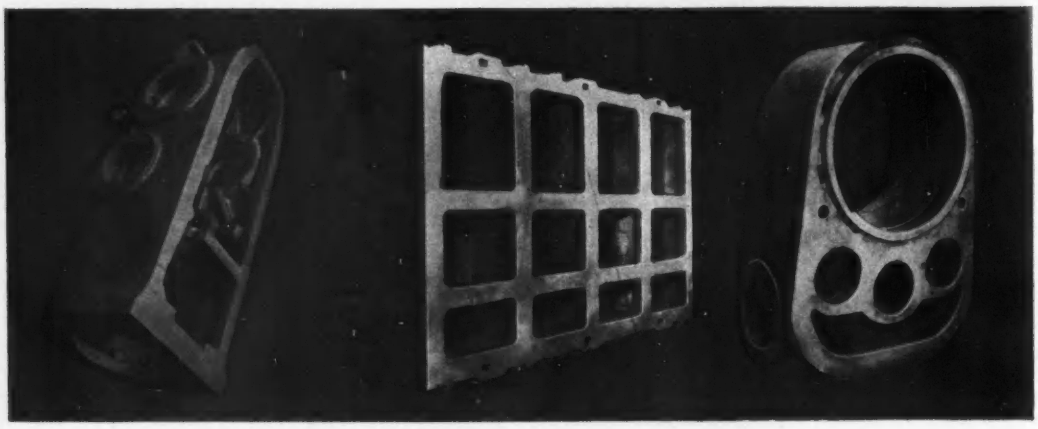
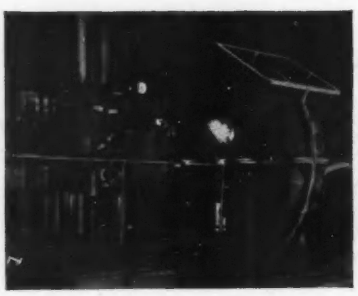


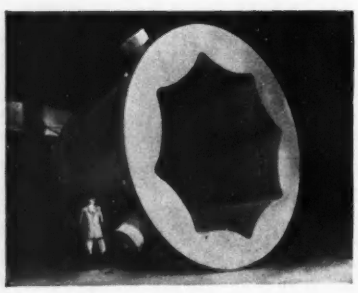


DISTINGTON ENGINEERING COMPANY LIMITED

WORKINGTON CUMBERLAND ENGLAND

120 TONS





120 tons is the maximum weight of iron casting that we can produce. We regret to have to turn down enquiries for one piece wide-span bridges (too heavy) and also enquiries for candelabra (too small and thin.) We do not machine gasholders from the solid in case we should spoil them on the last cut.

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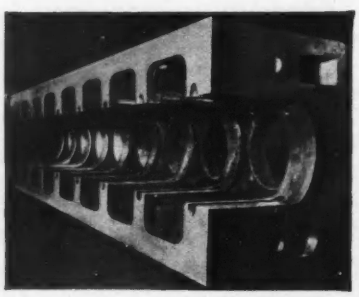

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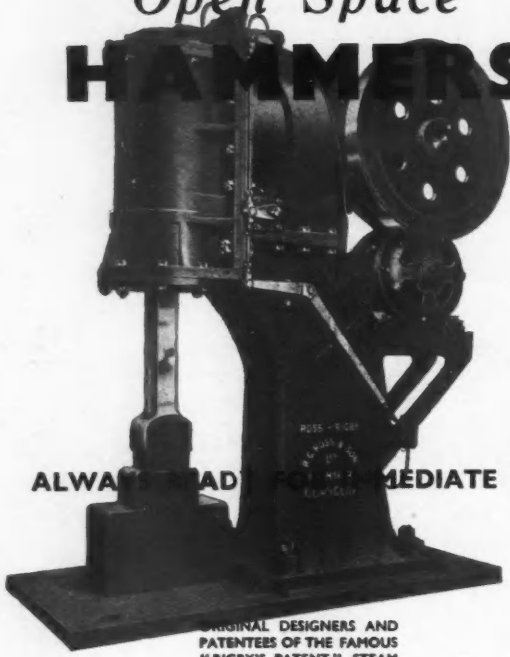

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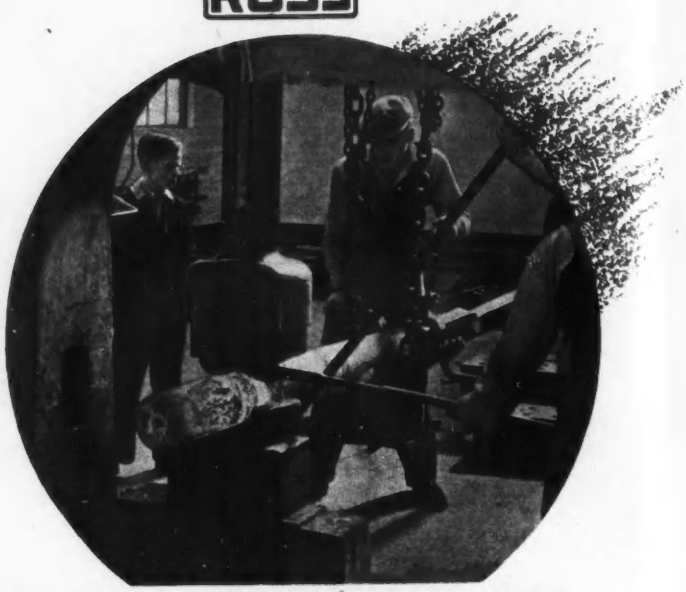

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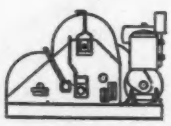

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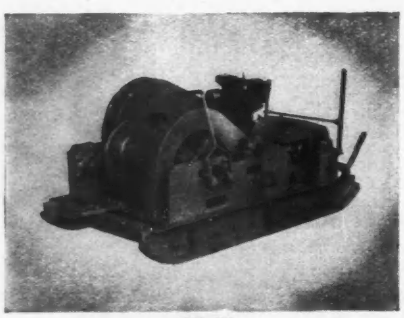

FIG. 229
Petrol driven two-speed hoist giving hoisting speeds of 10 and 30 ft/min. with a maximum load of one ton. Used for the erection of steel pylons, the hoist is mounted on skids, it is arranged for self propulsion by pulling on an anchored rope through a return block.

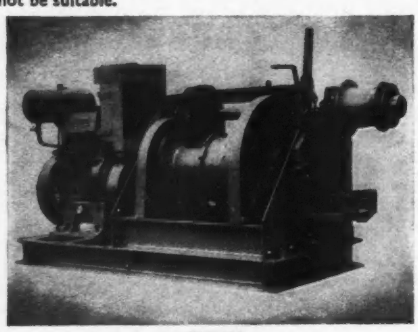

FIG. 228
Diesel driven winch with a divided barrel of two diameters and one warping drum, used for cargo handling on coastal motor ships.

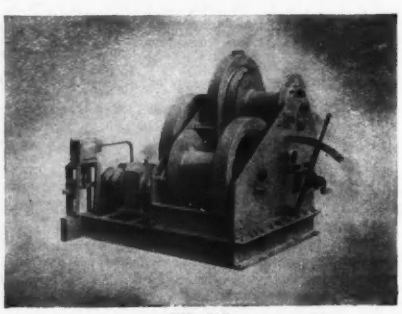

FIG. 227
One of a pair of Electrical reversible hoists specially designed to be accommodated within a confined space; one being right hand as illustrated and the other left hand; each hoist fitted with a solenoid operated brake as well as foot brakes, each barrel being suitable for a 3½ ton load; used in connection with a screw piling outfit.

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ASK ANY SAILOR ABOUT RUST—he knows the dangers of rust on ships. What he may not know is that the surest means of preventing rust is hot galvanizing. Hull plates to handrails, anchors to davits—all need galvanizing. In fact, wherever steel is used . . . in factories and mines, on railways and farms . . . there is no substitute for hot galvanizing. The tenacity and durability of *hot* galvanizing ensure lasting protection with minimum maintenance.

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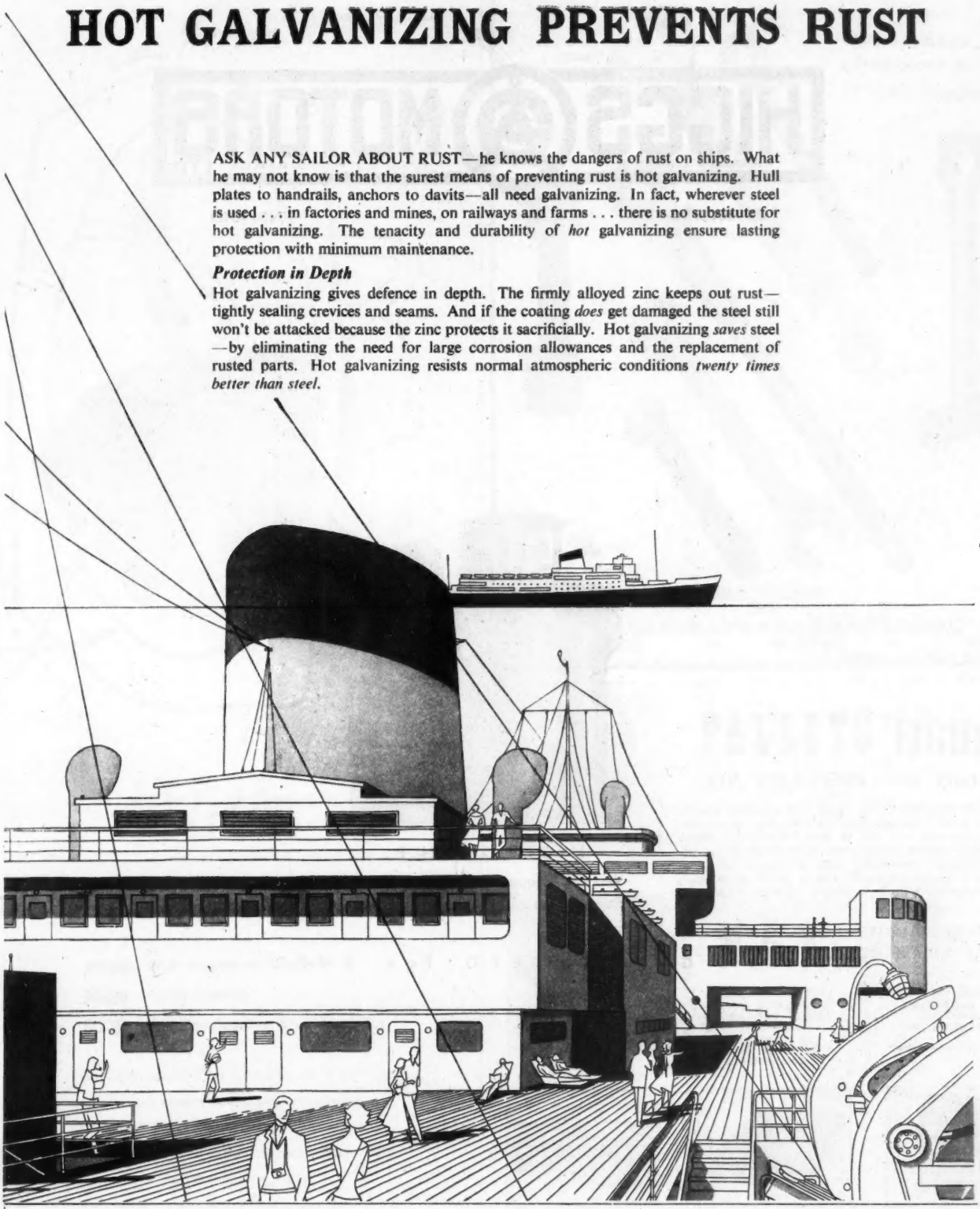

Hot Dip Galvanizers Association

The Hot Dip Galvanizers Association, a non-trading body, welcomes enquiries. Write to 34 Berkeley Square, London, W.1
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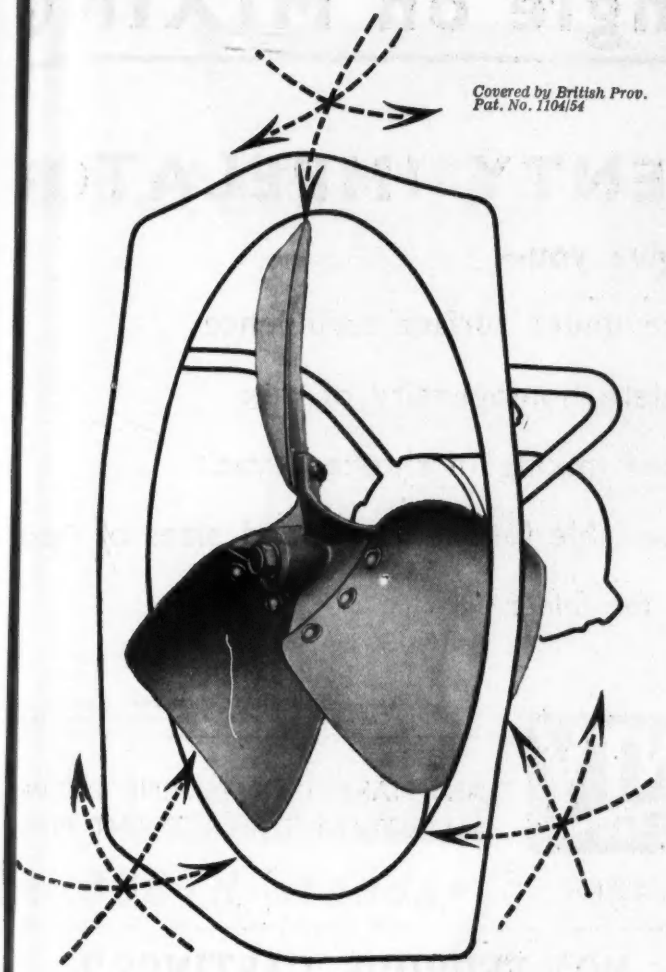

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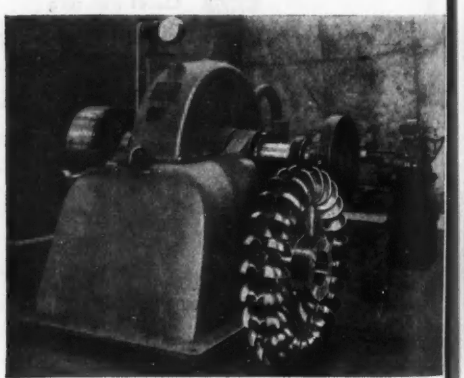

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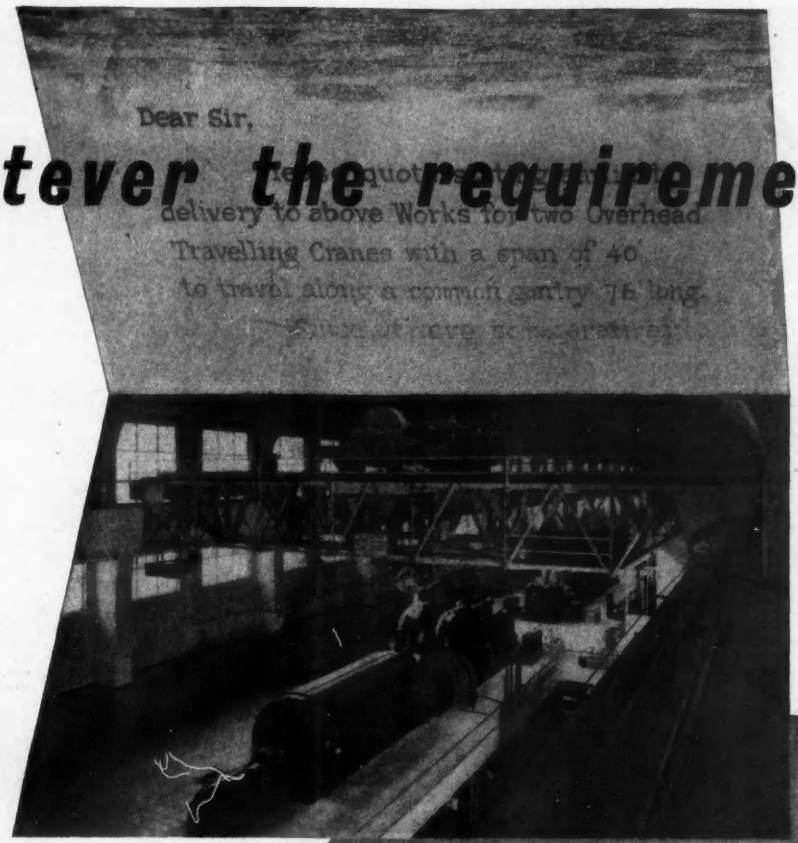
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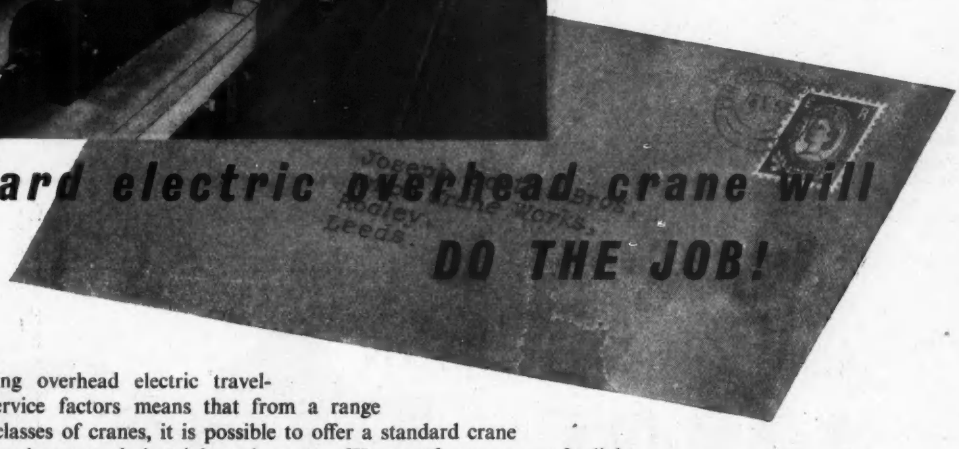

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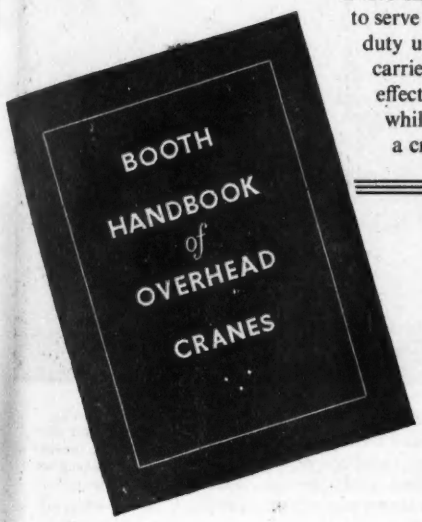

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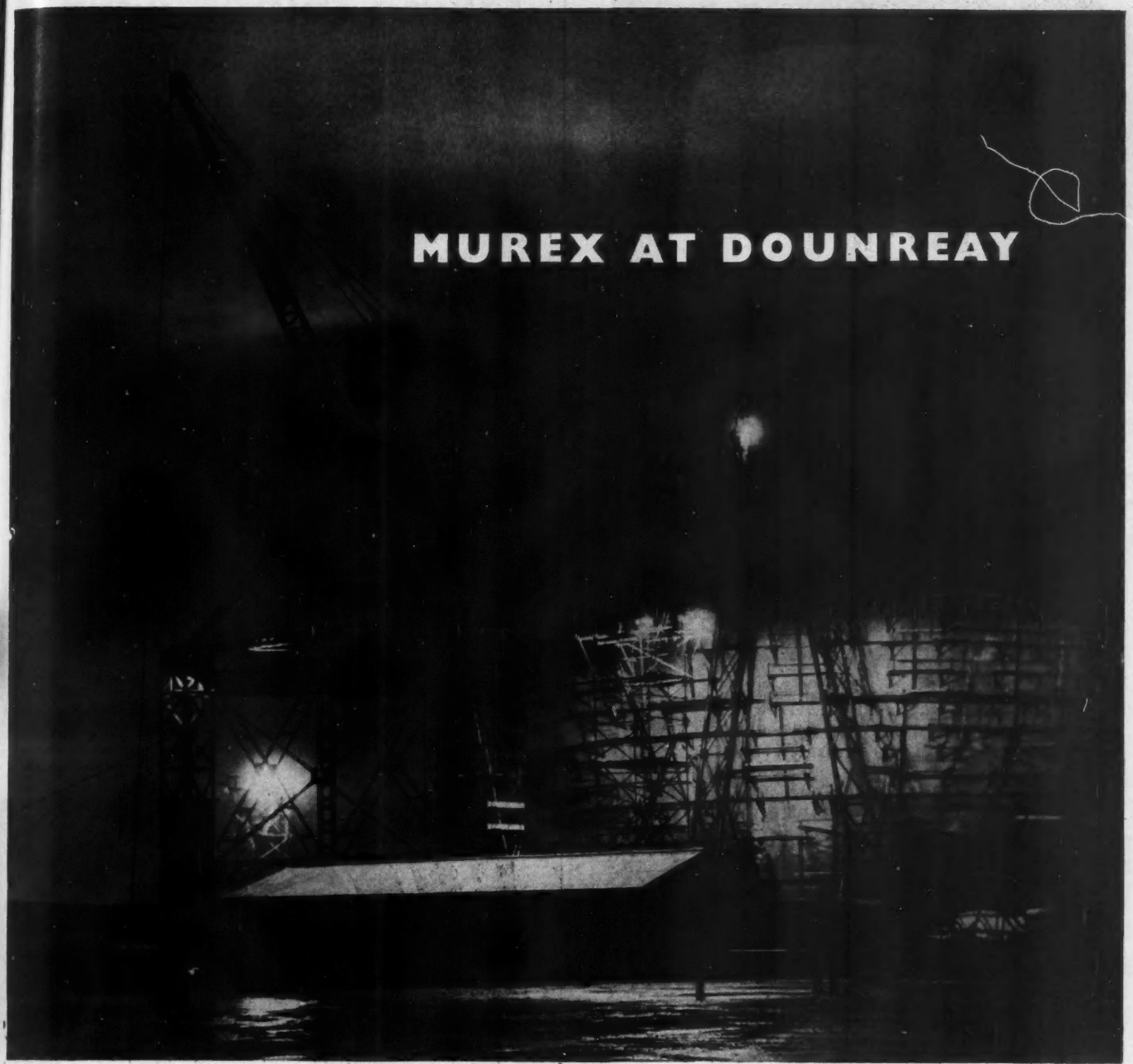

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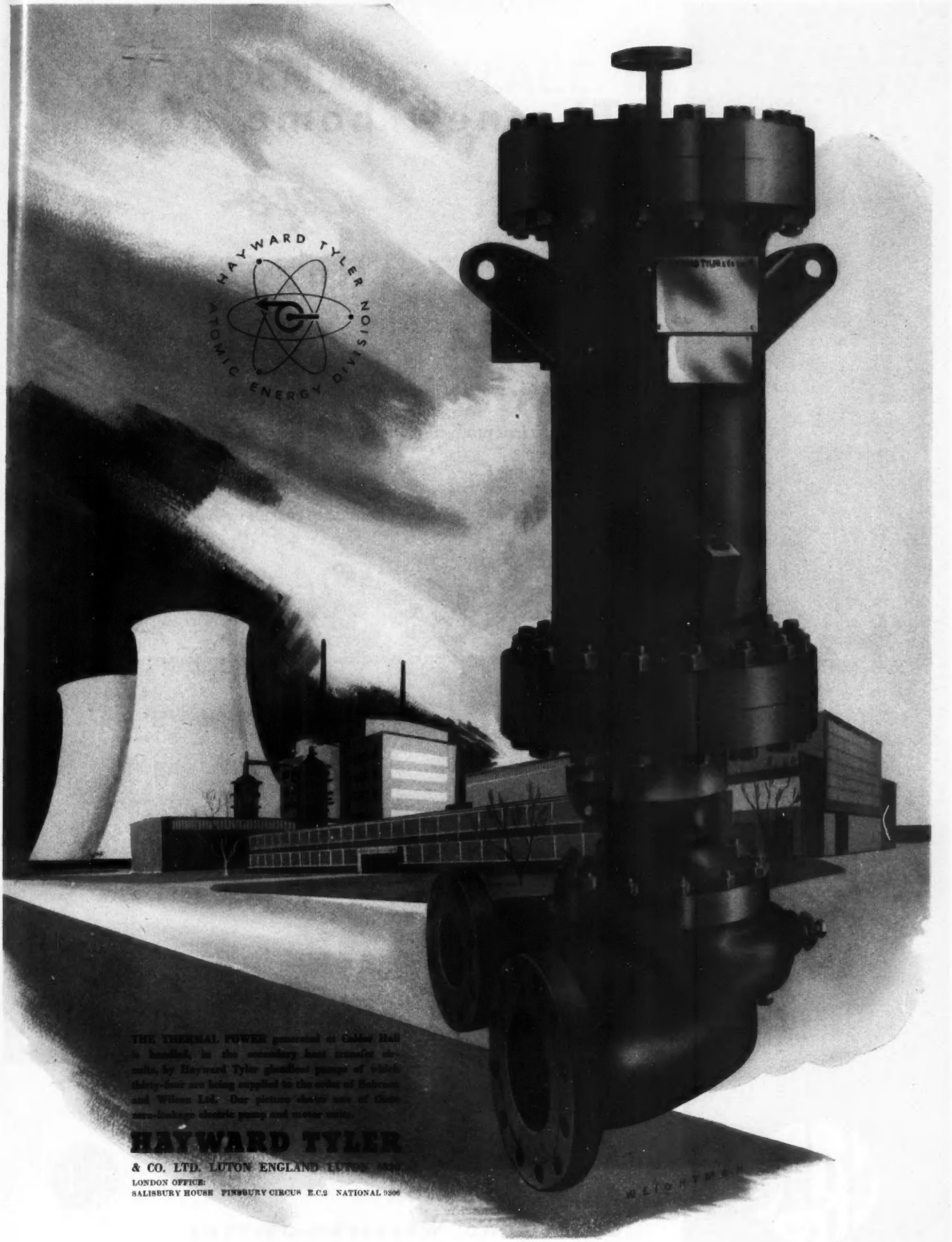

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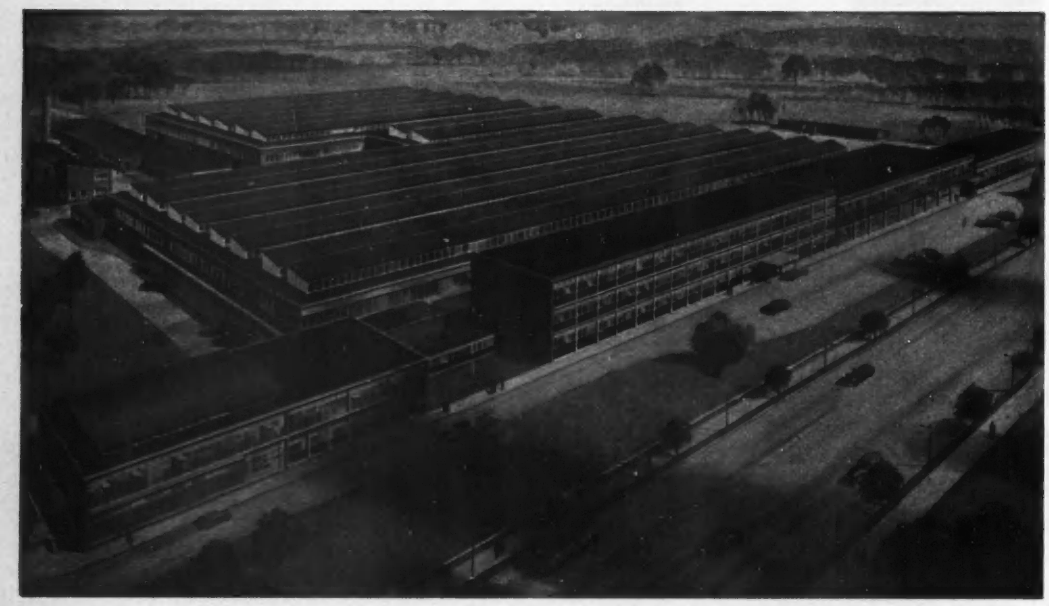

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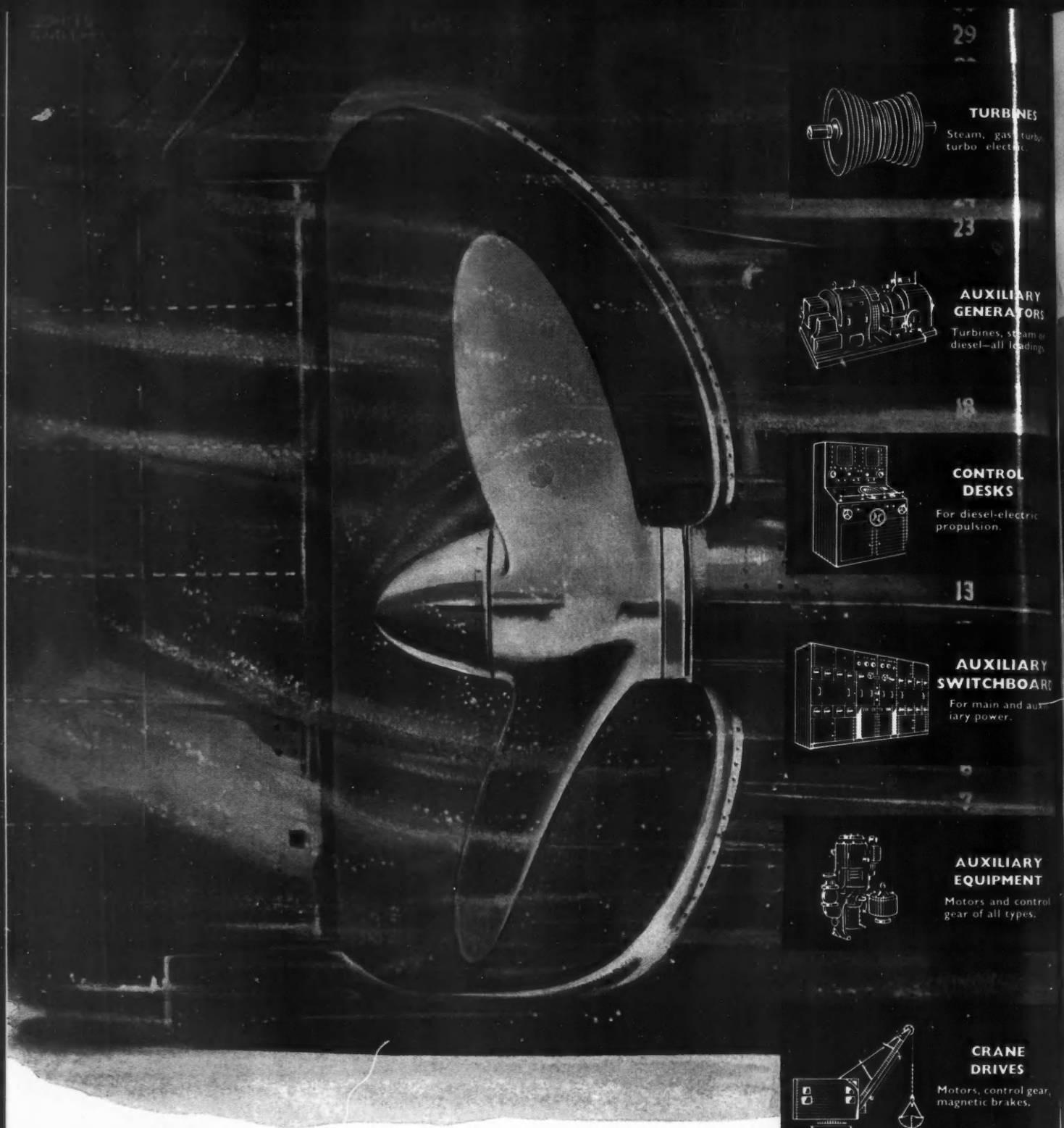

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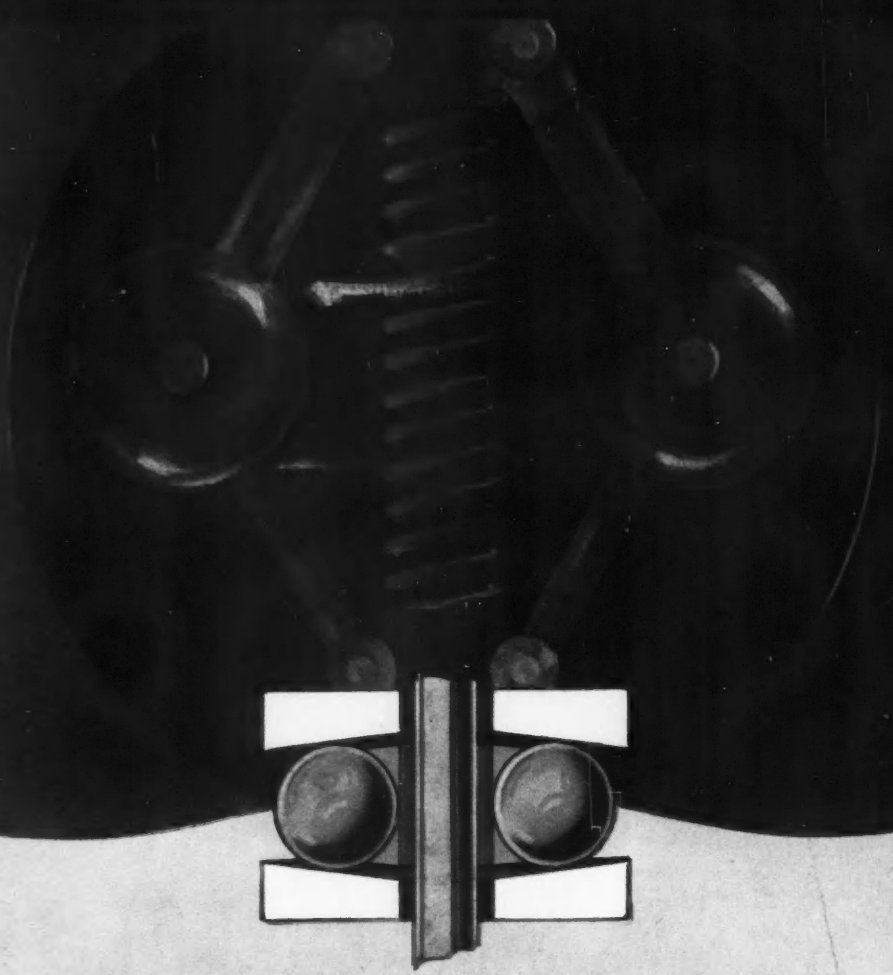

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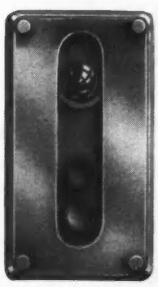

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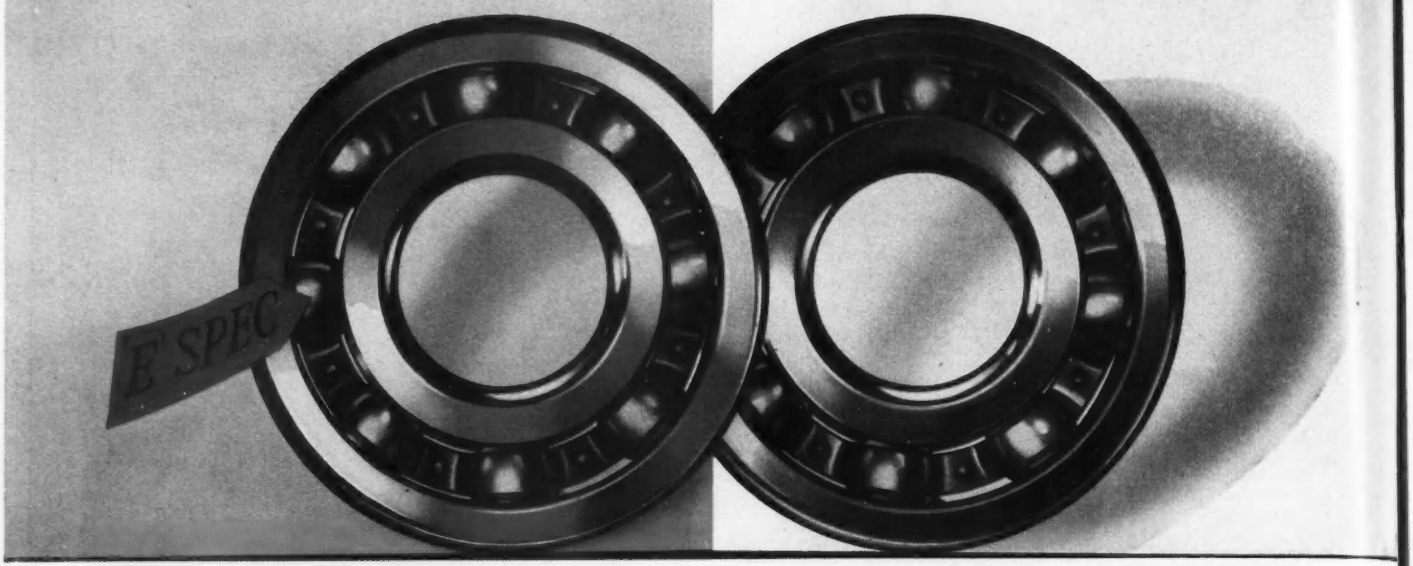

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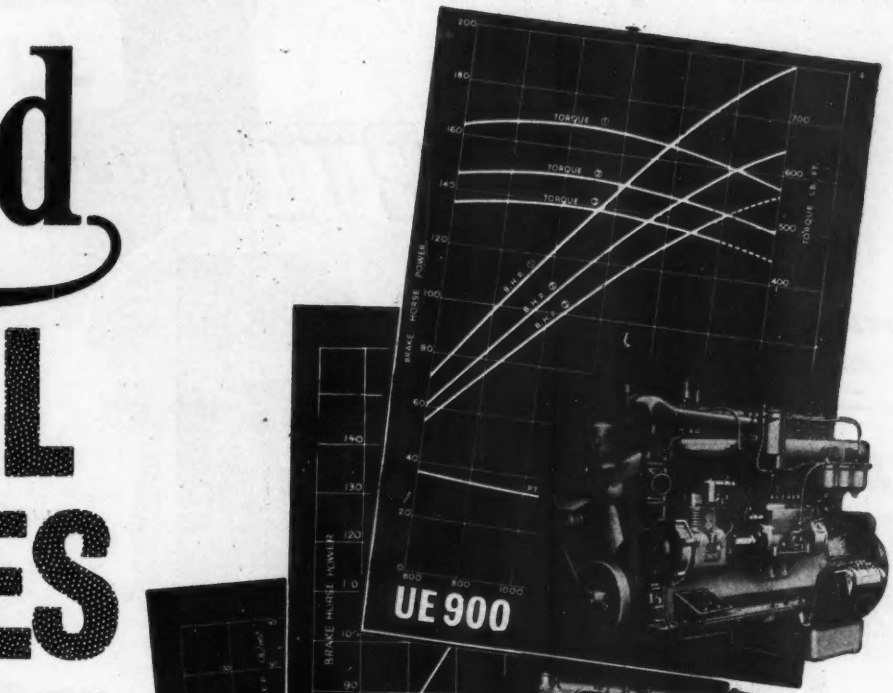

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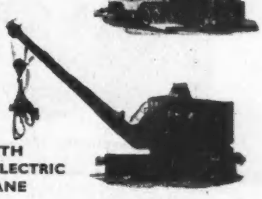

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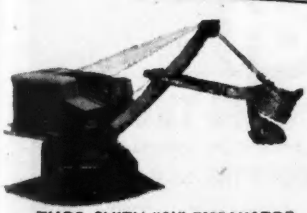

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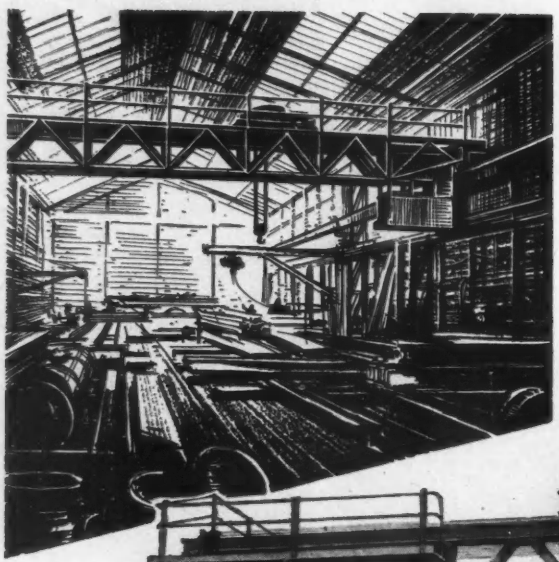
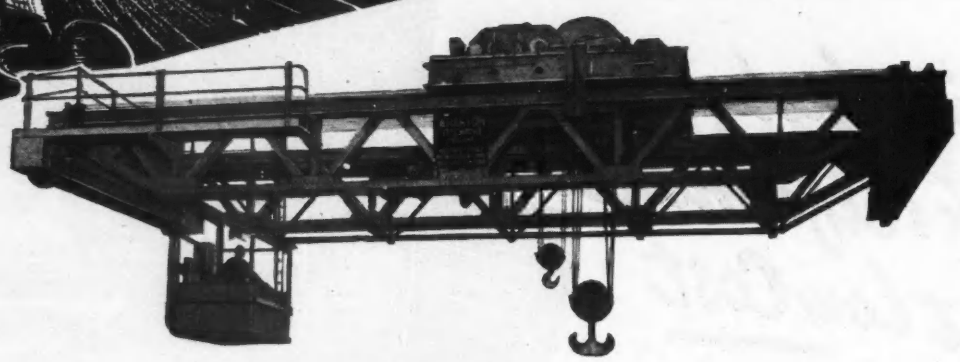


50

years of consistent progress



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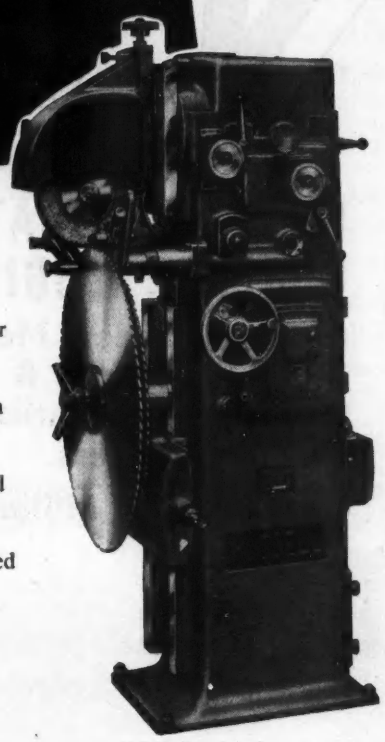

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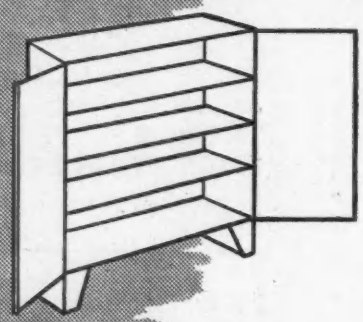

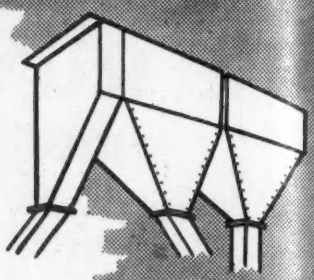

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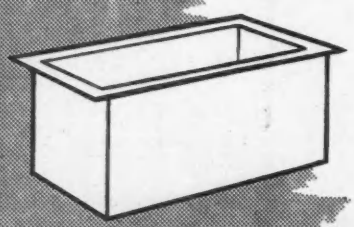

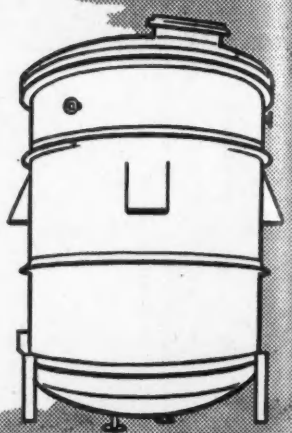

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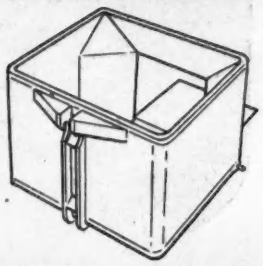
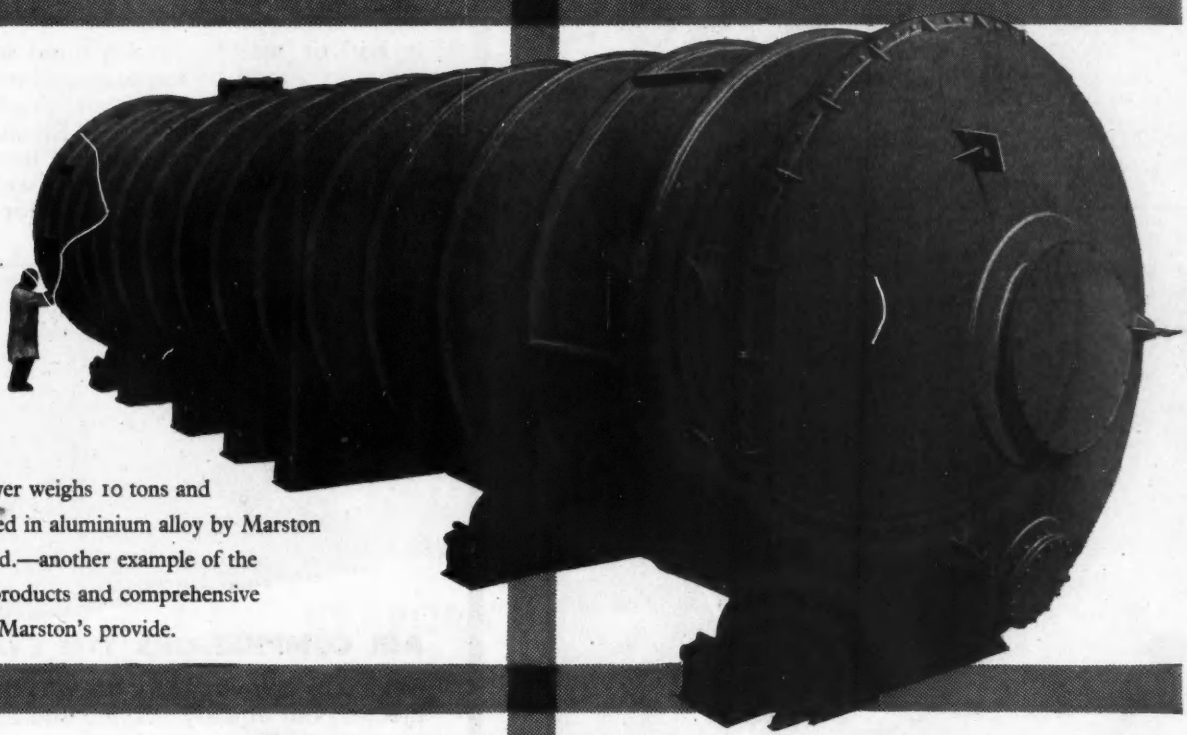
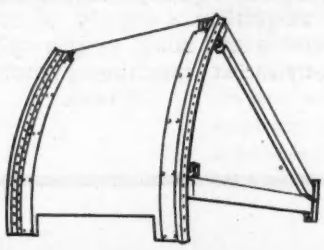


This truck-container is designed to carry granular material of particle size approximately $\frac{1}{16}$". Special attention had to be paid to the fit of the door and the smooth finish of the interior. The body ($\frac{1}{8}$" Plate Kynal M 39/2) was welded by the Argon arc and Argonaut processes.



This 52′ tower weighs 10 tons and was fabricated in aluminium alloy by Marston Excelsior Ltd.—another example of the specialised products and comprehensive service that Marston's provide.



This radial sluice-gate is 6′ 6″ wide and 6′ high. It is made of aluminium alloy, to minimise maintenance costs. To obtain a clean design free from any crevices where corrosion might start, the gate was welded by the Argon arc process. It is believed to be one of the first examples in this country of a radial sluice-gate in welded aluminium alloy.

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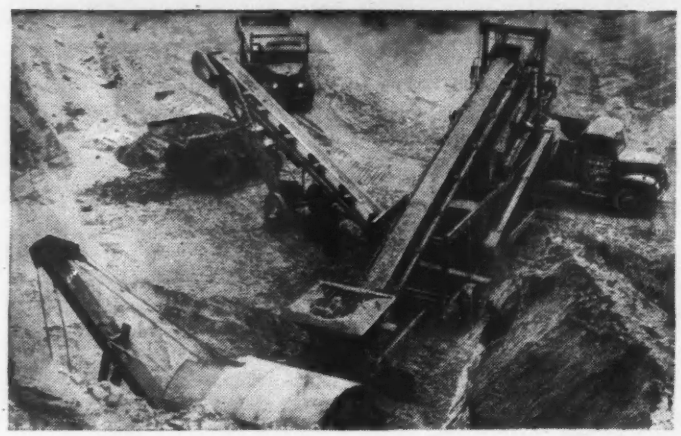

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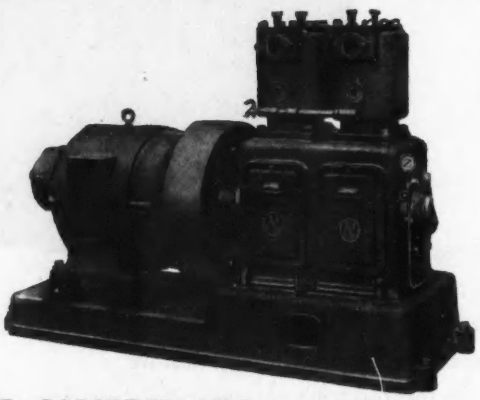

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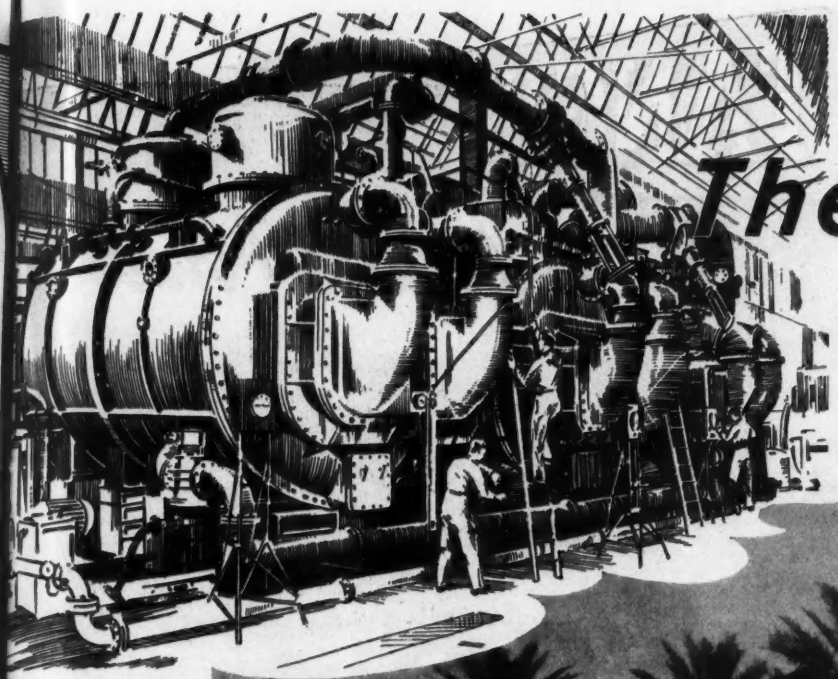

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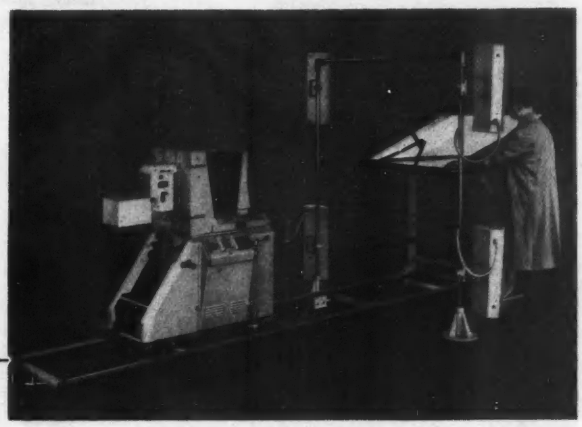

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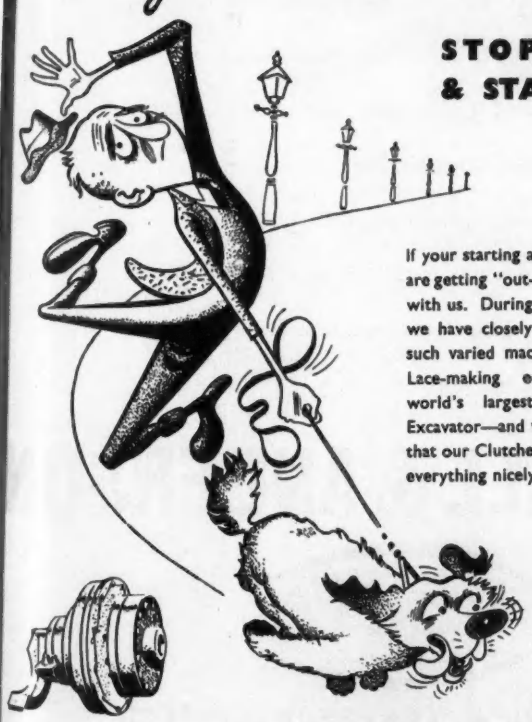

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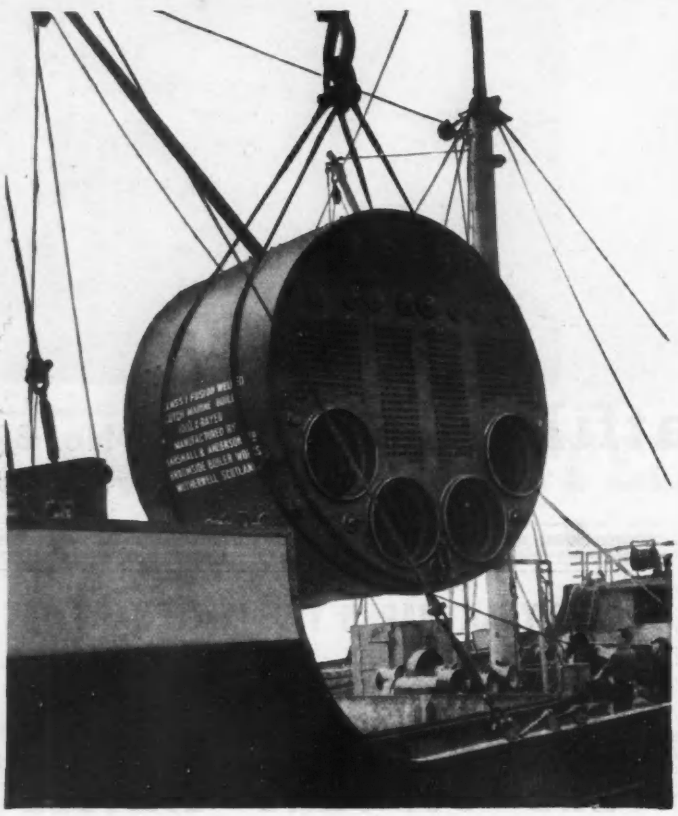

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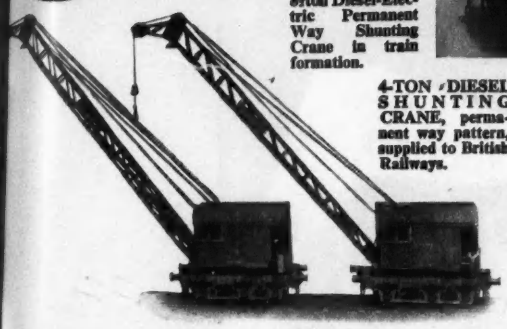

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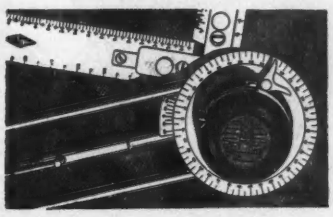

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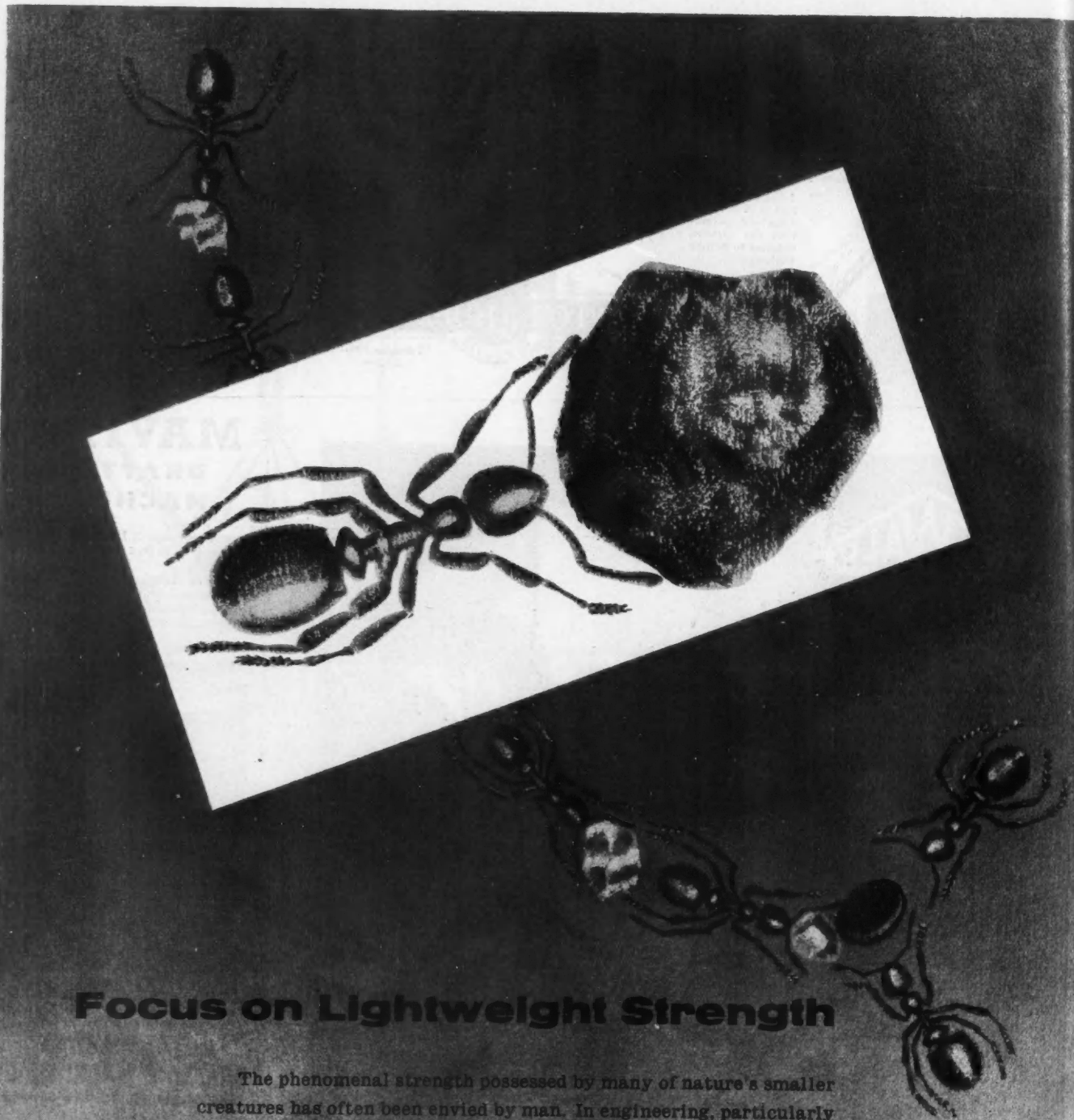

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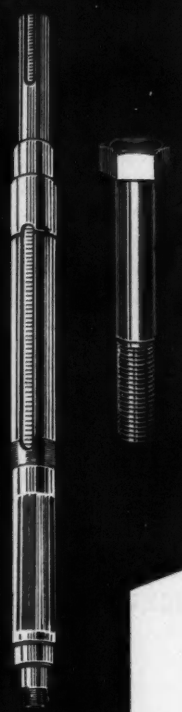

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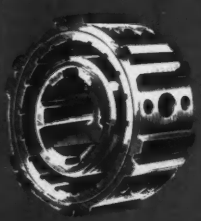

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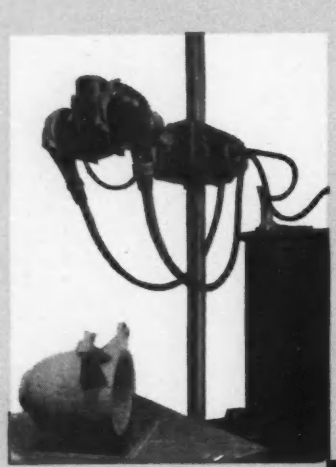

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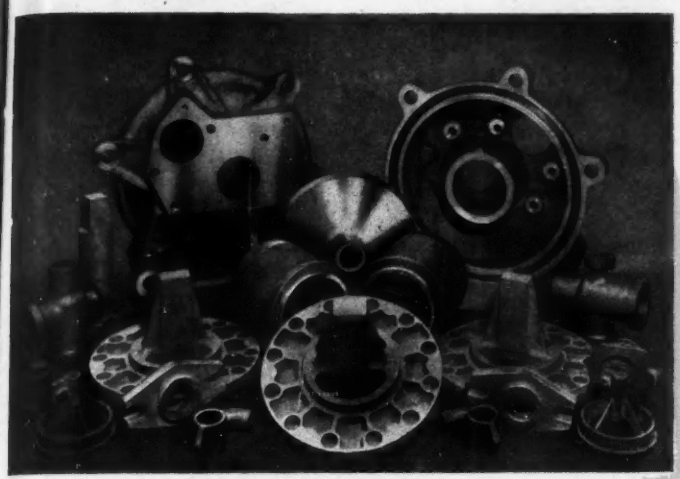
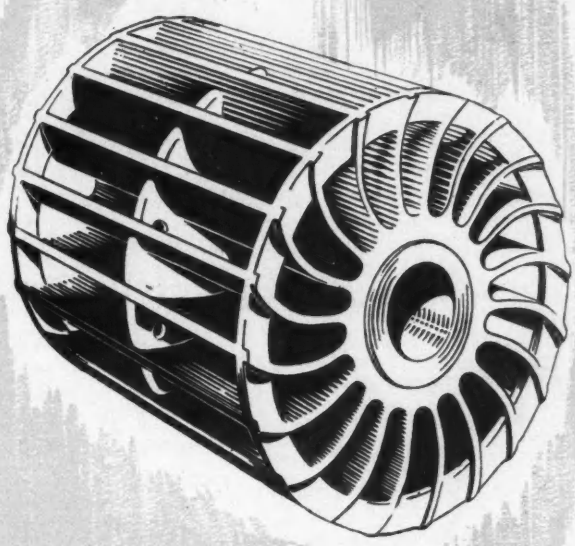


A selection of Shell Mouldings, showing machined surfaces.



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Remedy: "Oildag" 1:9 in light oil applied occasionally
Result: No sticking
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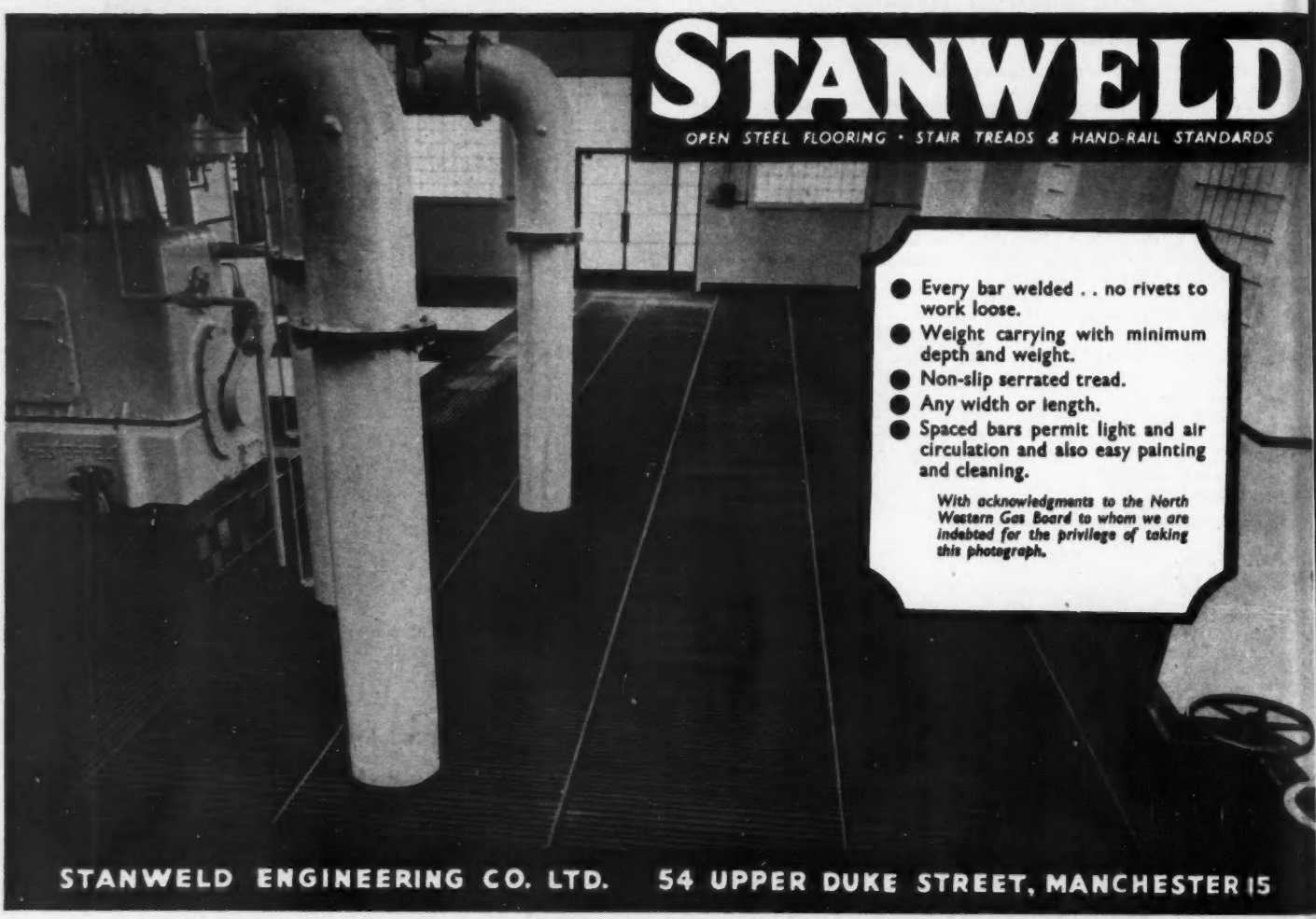
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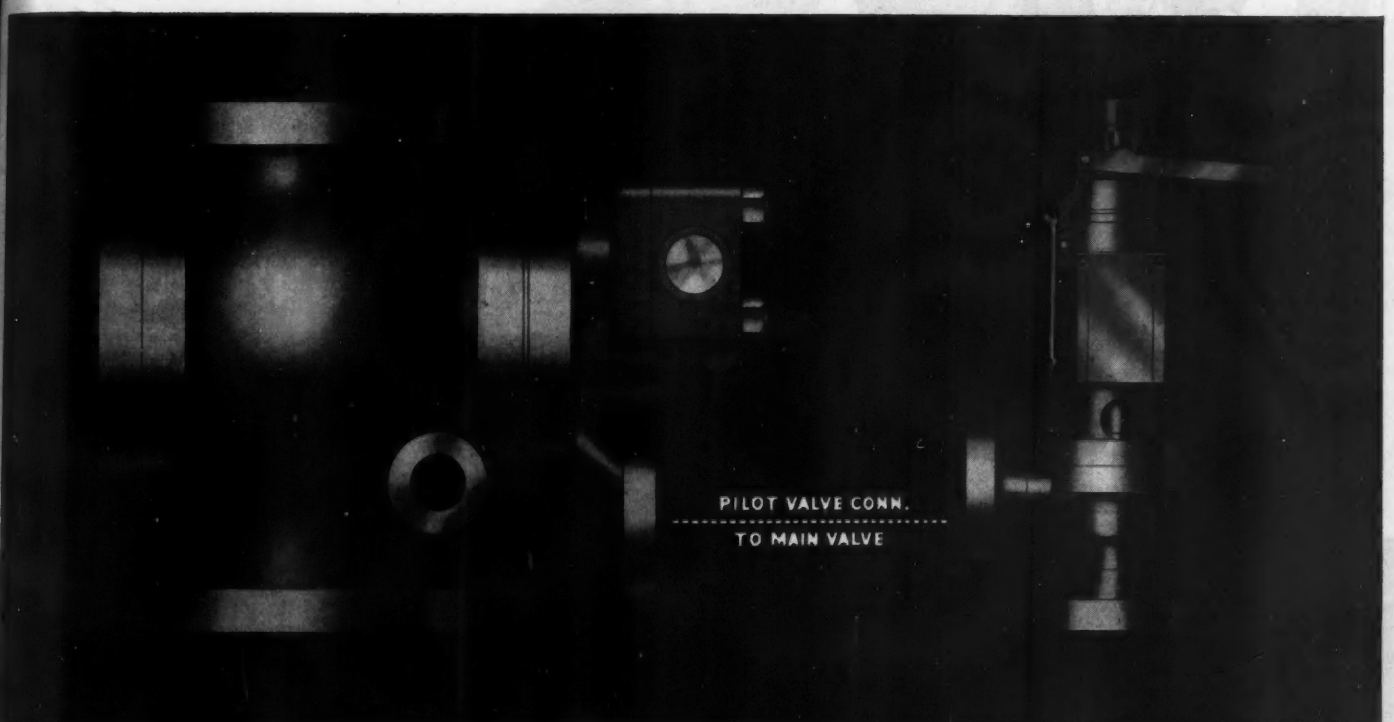

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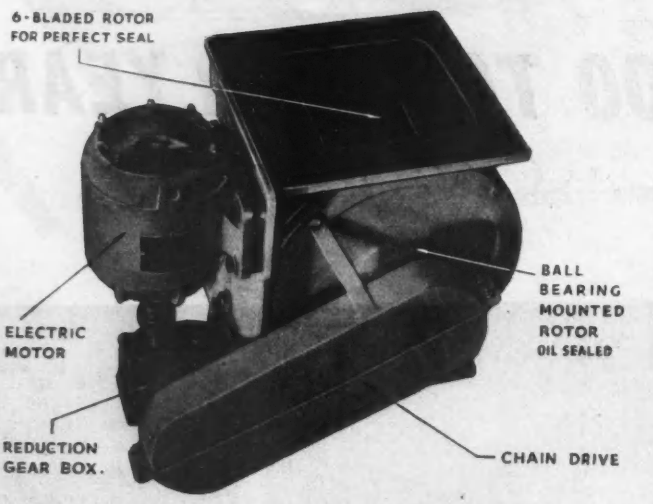

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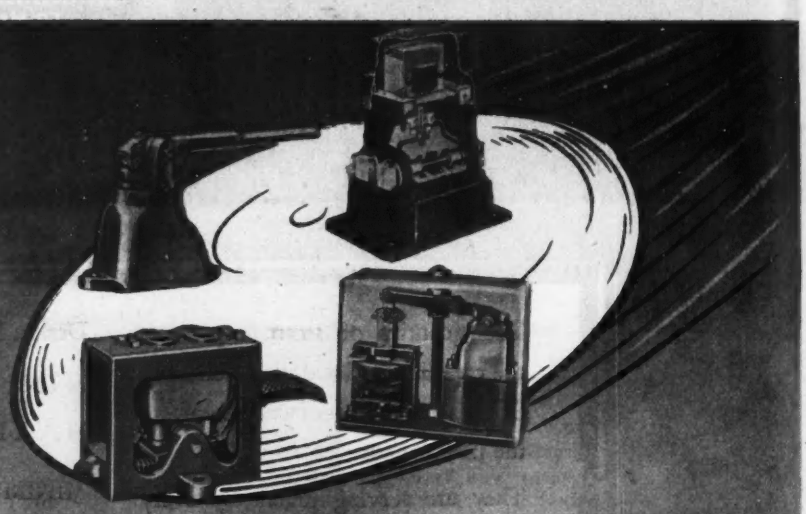

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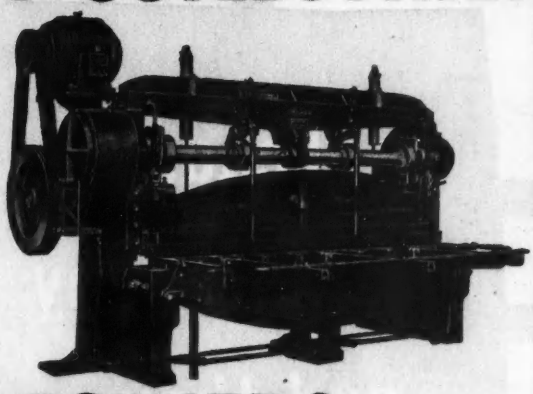

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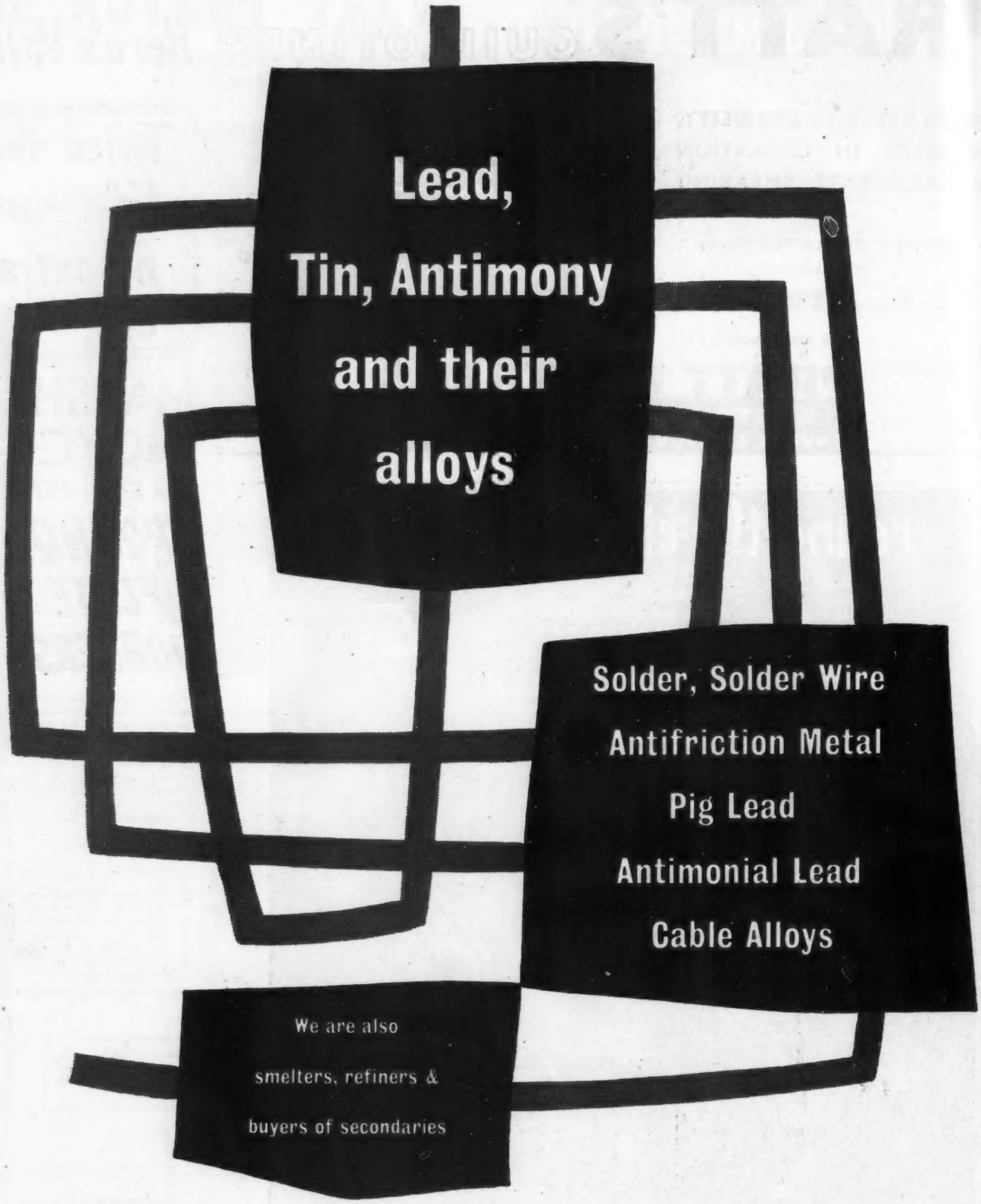

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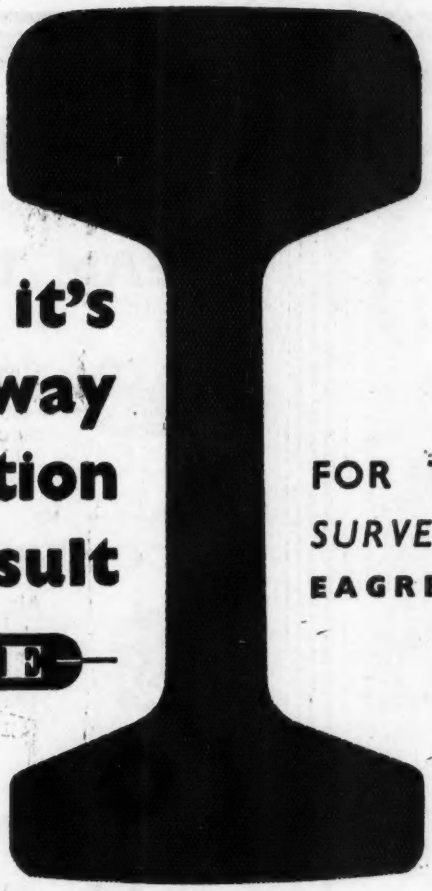

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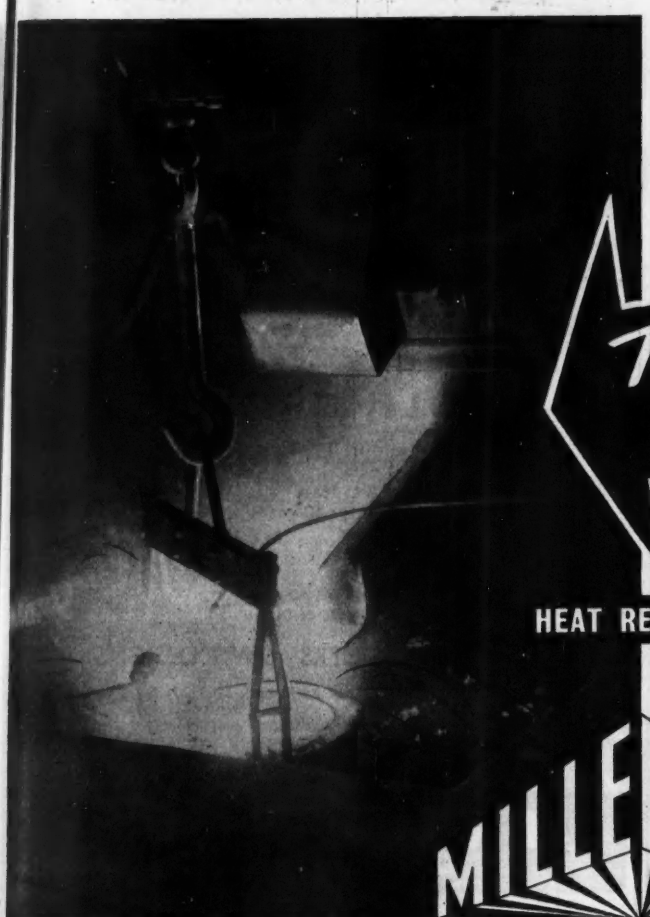

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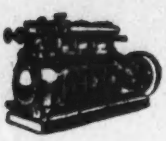

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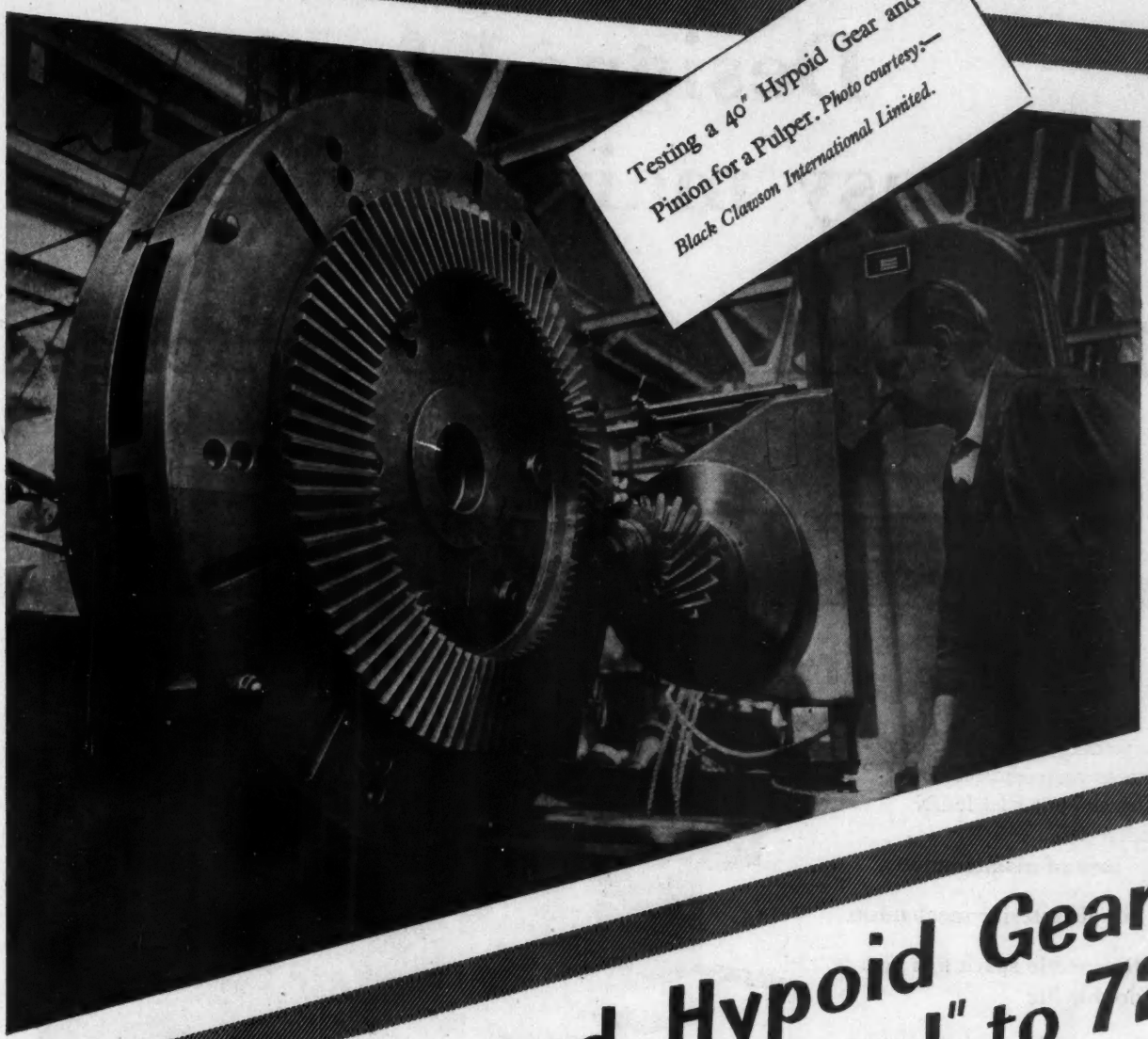

Testing a 40" Hypoid Gear and Pinion for a Pulper. *Photo courtesy:— Black Clawson International Limited.*

Spiral Bevel and Hypoid Gears from 1" to 72"

Spiral bevel and hypoid gears offer many advantages for right angle drives where high efficiency and smooth, silent running are required.

E.N.V. specialise in the design and manufacture of straight and curved tooth bevel gears. They offer collaboration with engineers from the project stage on the design of gears and mountings. They have unique facilities for the large-scale manufacture of transmissions including final drives, differentials and axles for vehicles and agricultural equipment, precision gears for aircraft and gears for industrial applications.

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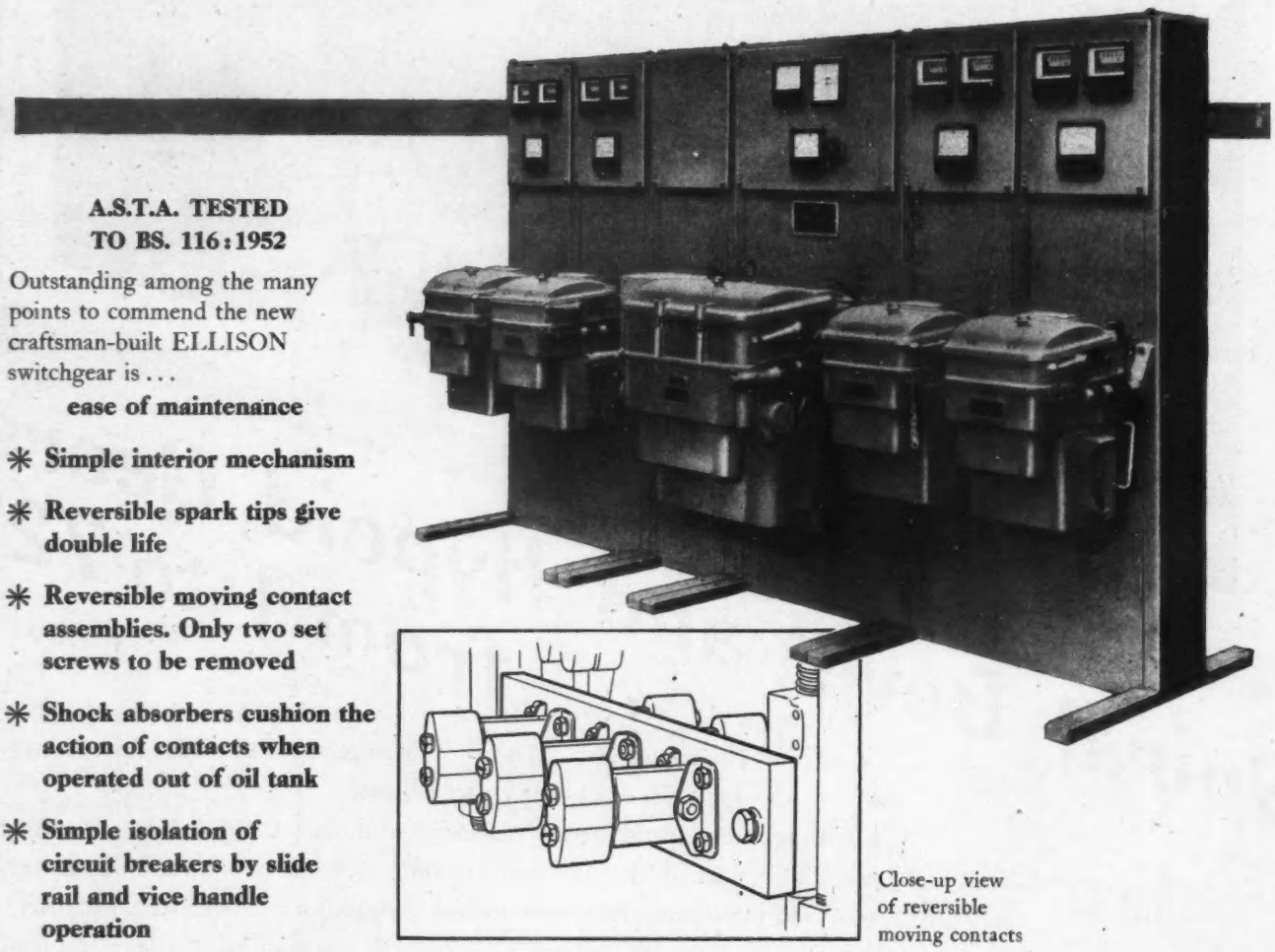
E.N.V. ENGINEERING COMPANY LIMITED *HYTHE ROAD, WILLESDEN, LONDON, N.W.10*

Designed for easy maintenance

The new Ellison GEO switchgear



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Outstanding among the many points to commend the new craftsman-built ELLISON switchgear is . . .

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- **Simple interior mechanism**
- **Reversible spark tips give double life**
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- **Simple isolation of circuit breakers by slide rail and vice handle operation**

Close-up view of reversible moving contacts

For further information please ask for Leaflet C.L. 244

1906 – 1956

GEORGE ELLISON LIMITED BIRMINGHAM ENGLAND

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Lockheed Avery

SELF-SEALING COUPLINGS FOR RAPID DETACHMENT

Without leakage of fluid or entry of air

STUD TYPE

Lockheed-Avery self sealing couplings enable fluid lines to be connected or disconnected whilst under pressure without loss of fluid. This stud type coupling is threaded for screwing into a socket connection and is available in bore sizes from ⅛ in. to 1½ in.

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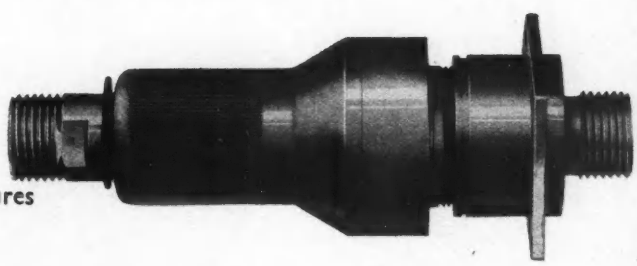

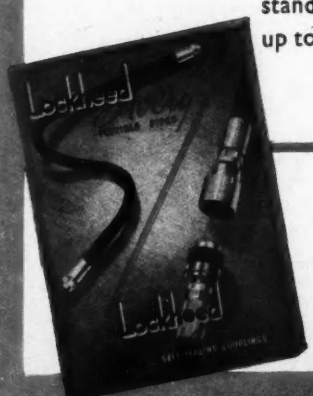

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Stourport 'B'	1	515	1550	1060	1954
Drakelow 'A'	4	515	1550	1060	1954-5
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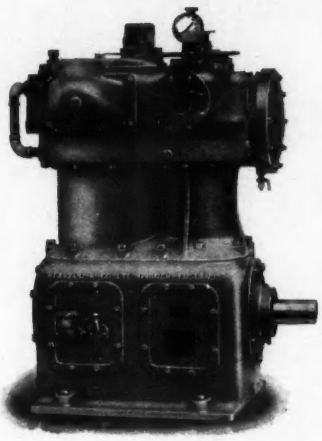

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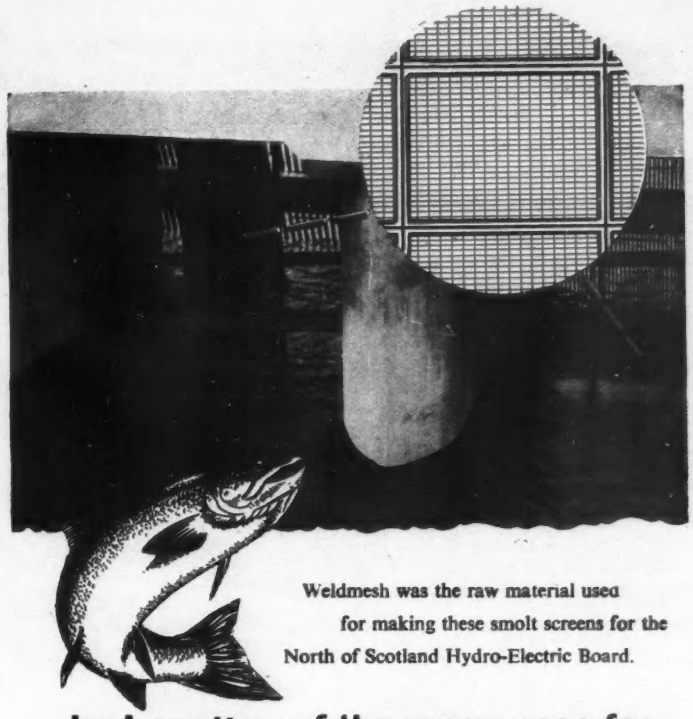

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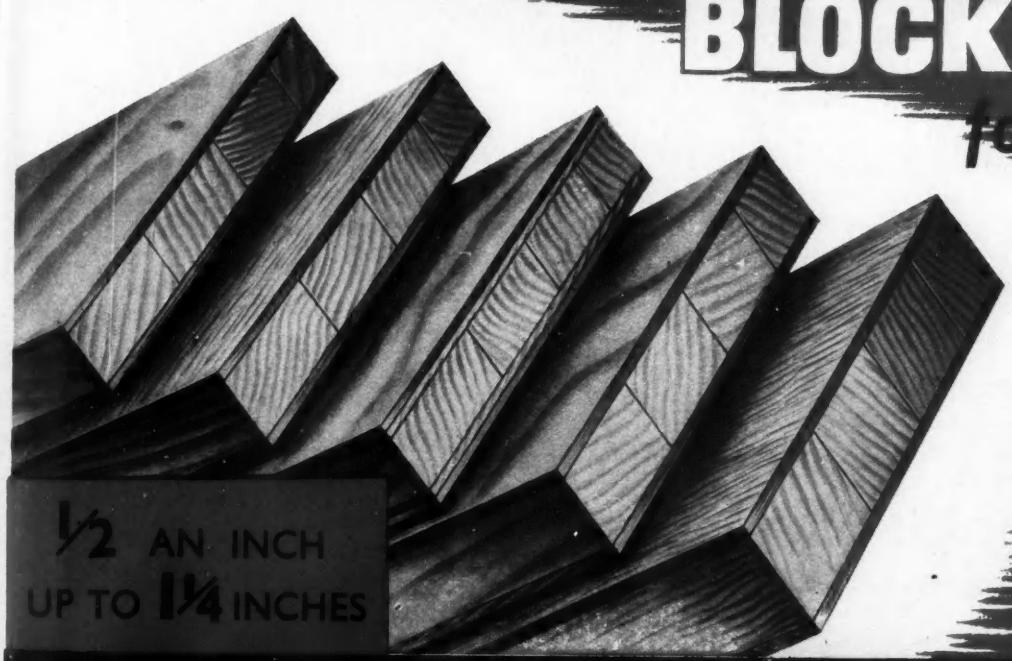

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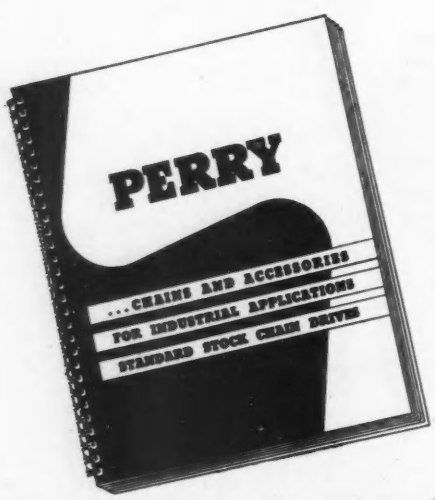

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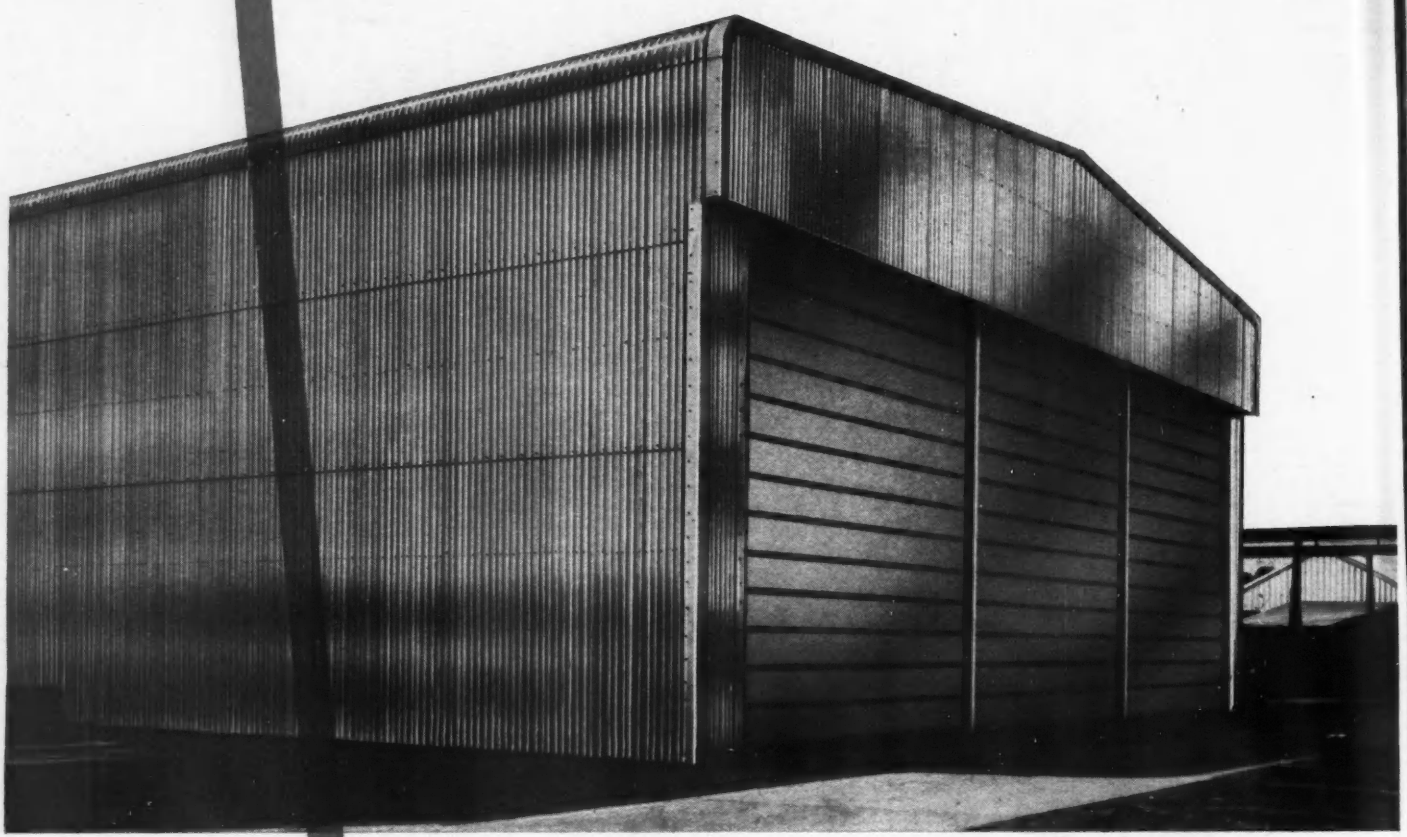

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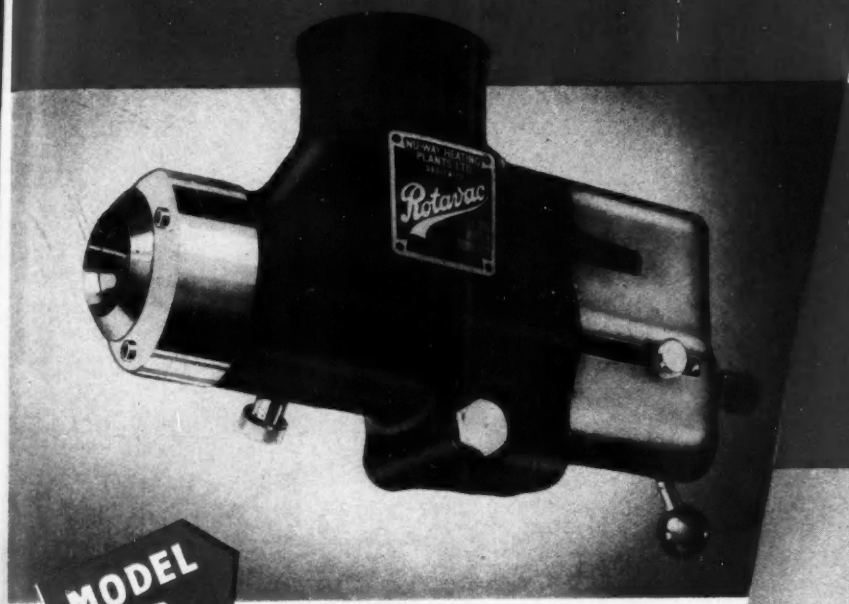

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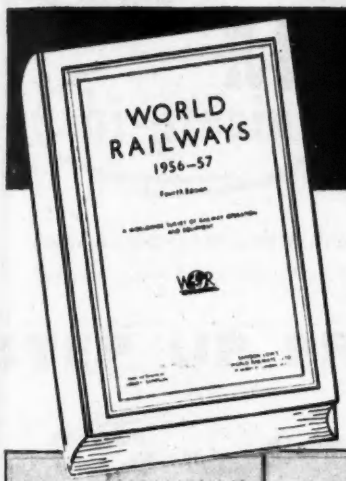

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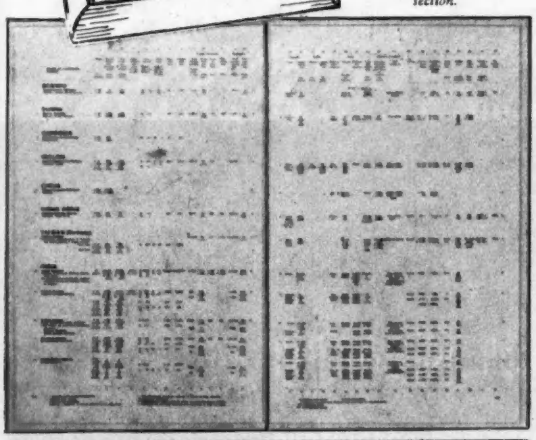

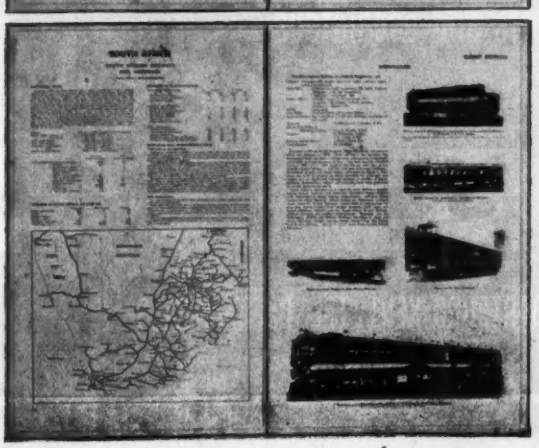

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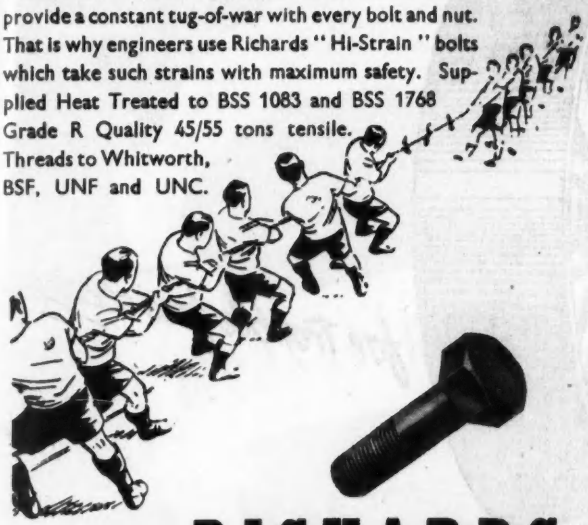

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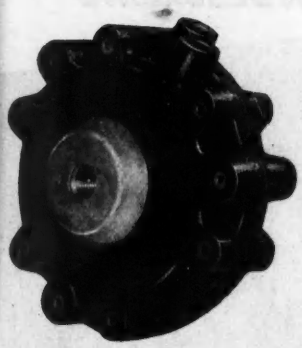

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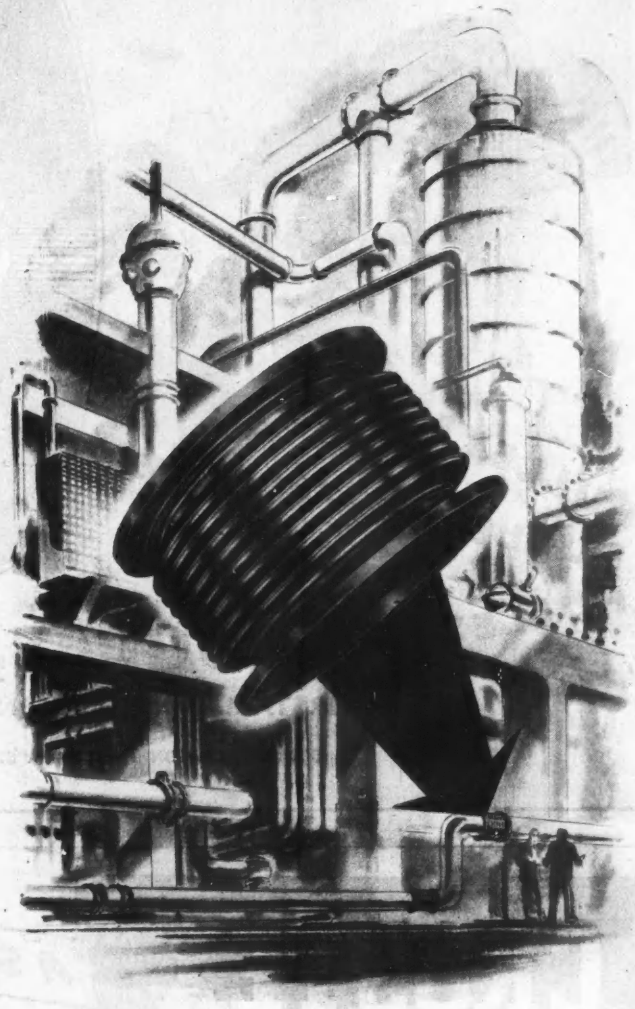

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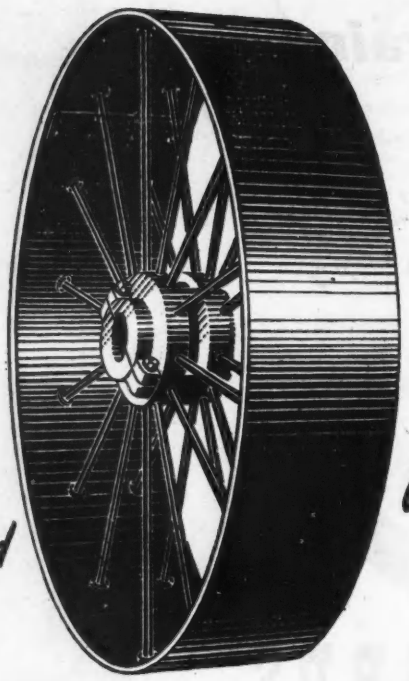

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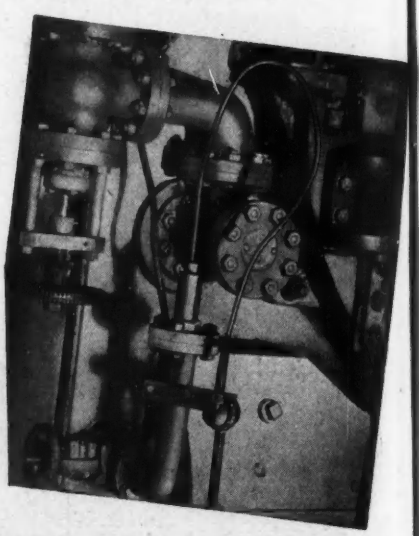

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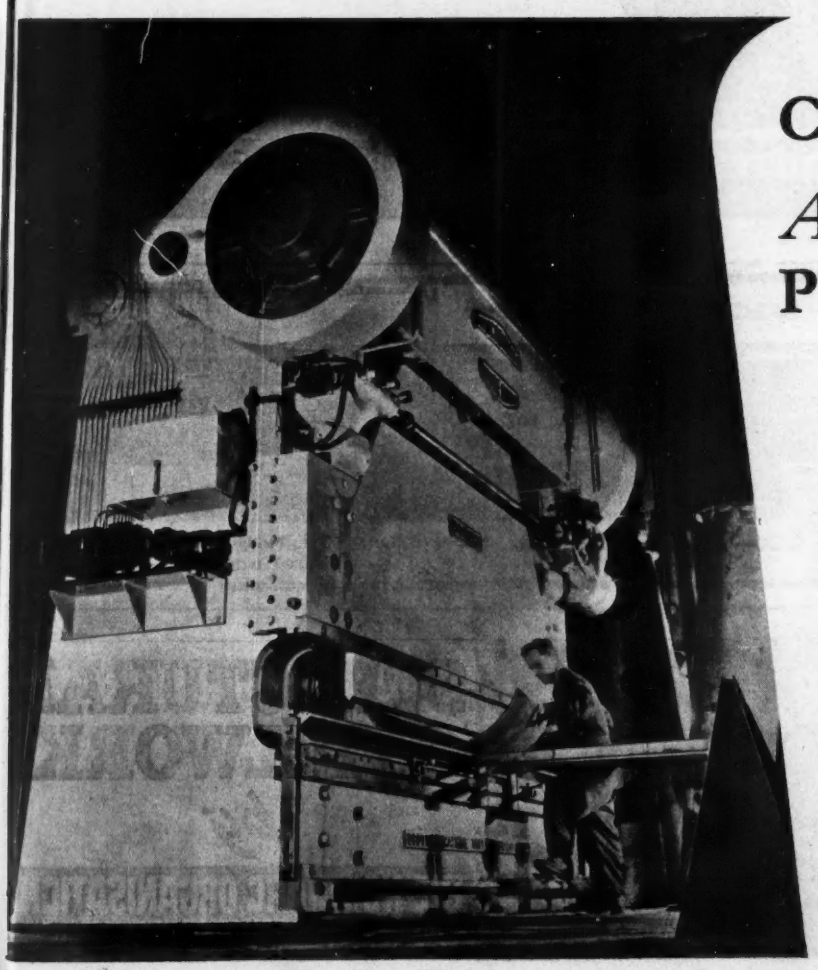

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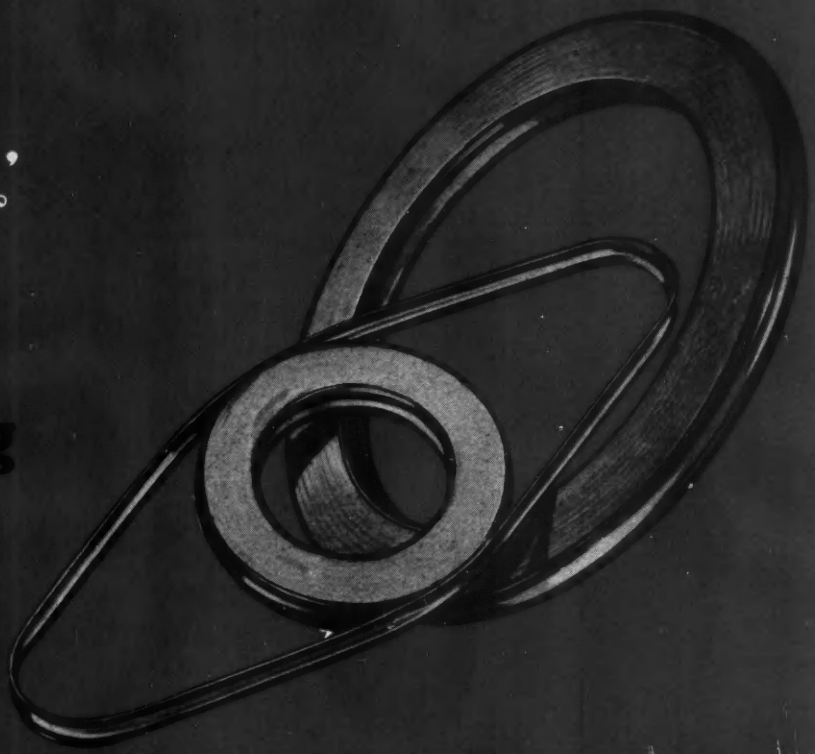

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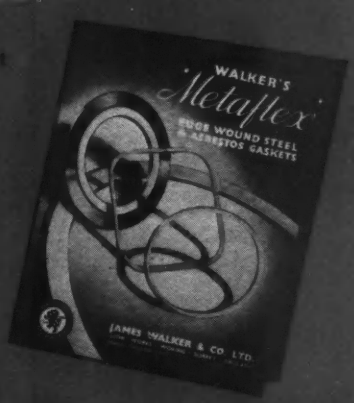

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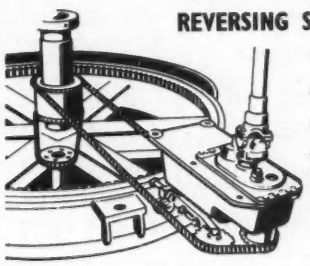

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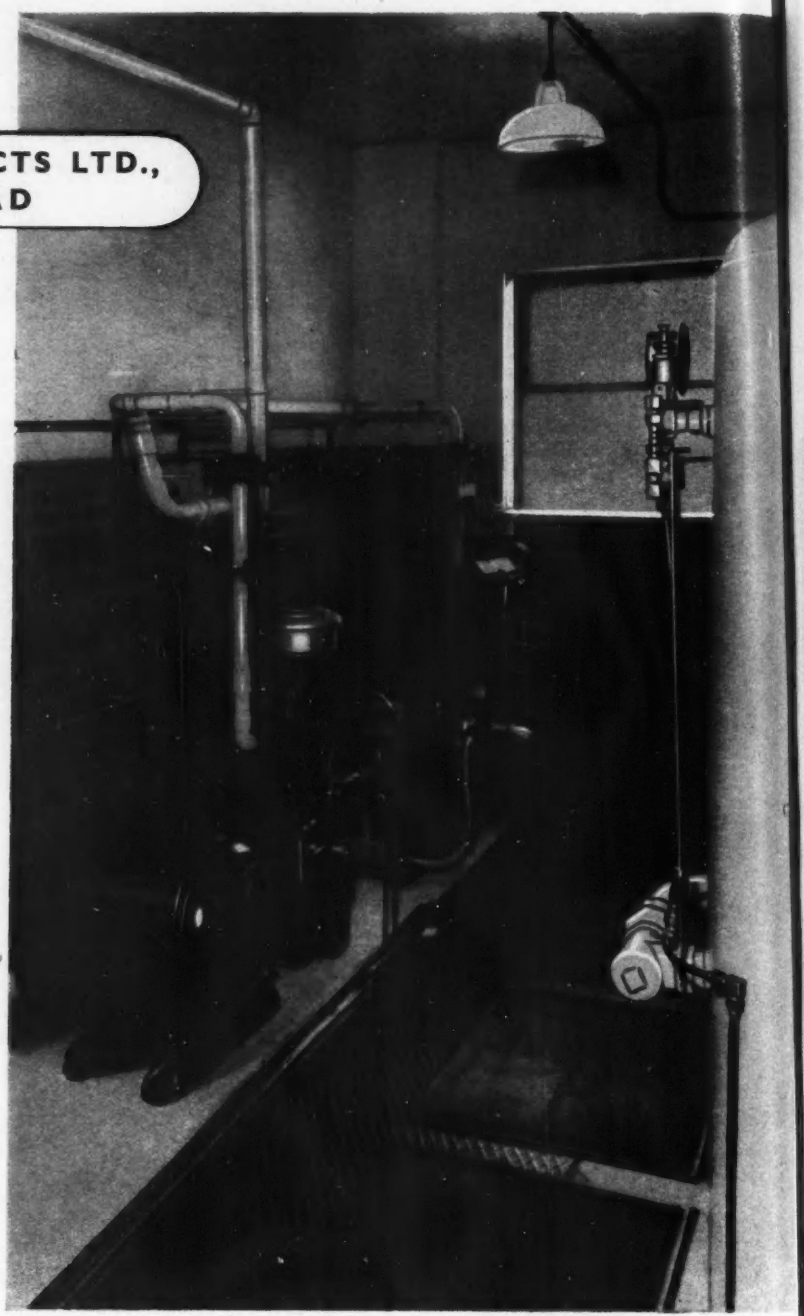

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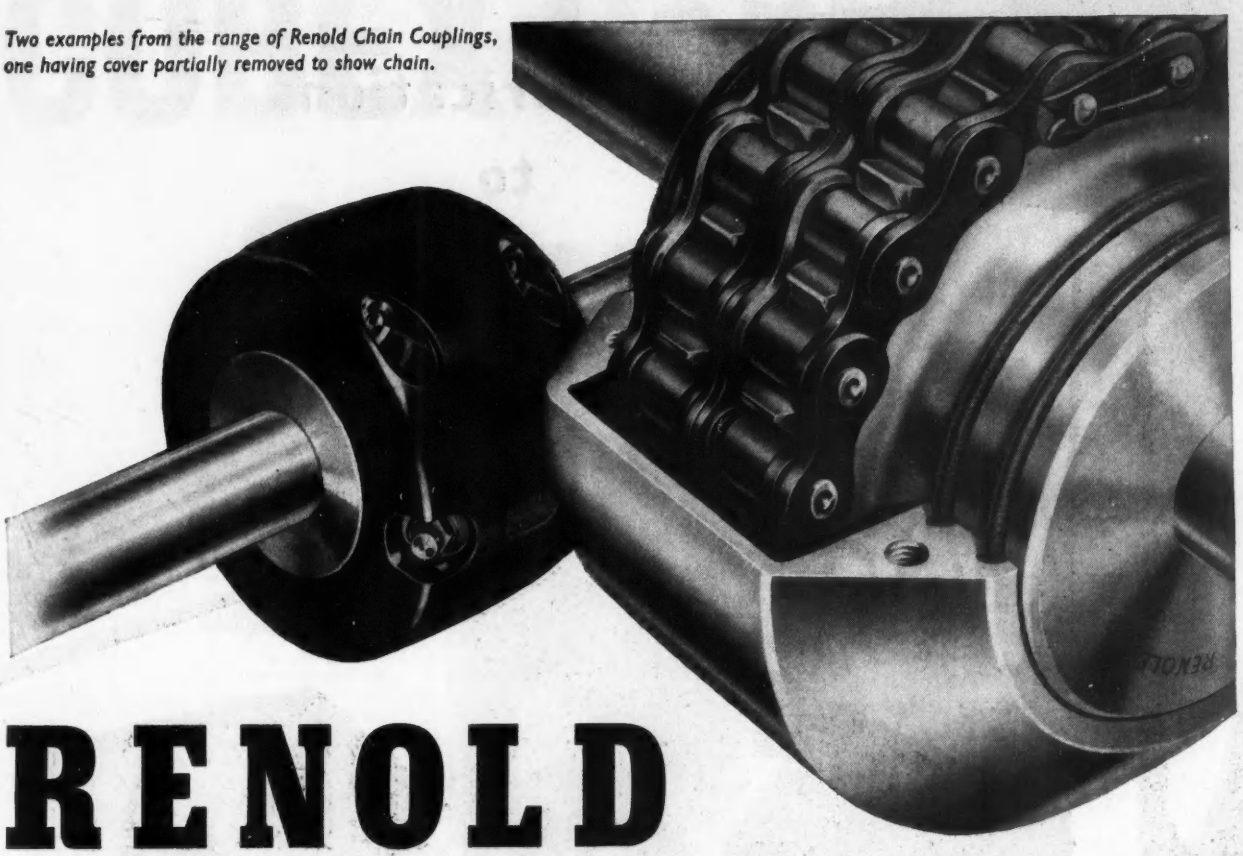
Two examples from the range of Renold Chain Couplings, one having cover partially removed to show chain.



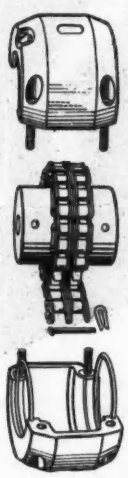
RENOLD

Chain Couplings

are designed throughout as robust, compact shaft couplings of all-steel construction, comprising two chain pinions encircled by a quickly detachable roller chain.
The enclosing cover is symmetrical, devoid of projections and ensures complete protection and lubrication of the working parts. A grease gun nipple is provided for replenishment of lubricant. The coupling is designed to accommodate small errors in shaft alignment, but care in lining up will be repaid by an almost indefinite coupling life.

Typical transmitting capacities —AC motor speeds		
h.p.	r.p.m.	Coupling No.
7.5	2,920	642 564
20	1,450	642 566
80	975	642 511
200	730	642 513
750	585	642 516
1,100	490	642 517

Available in 11 sizes—maximum 1,500 h.p.



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Minimum size for maximum h.p. capacity.

easily uncoupled
Simply remove cover and detach duplex roller chain.

robust
Constructed entirely of steel. Smooth, easily removed, dust-tight cover contains lubricant and ensures complete protection.

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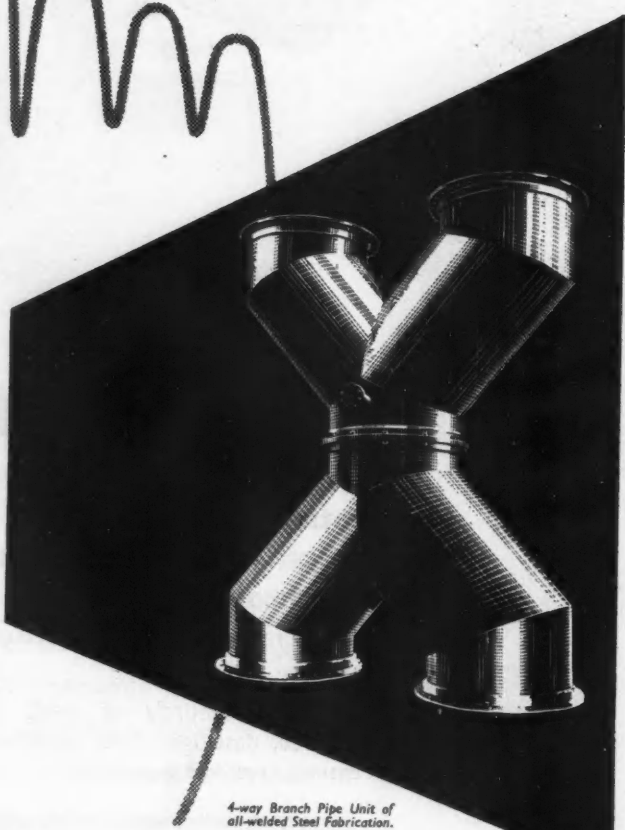
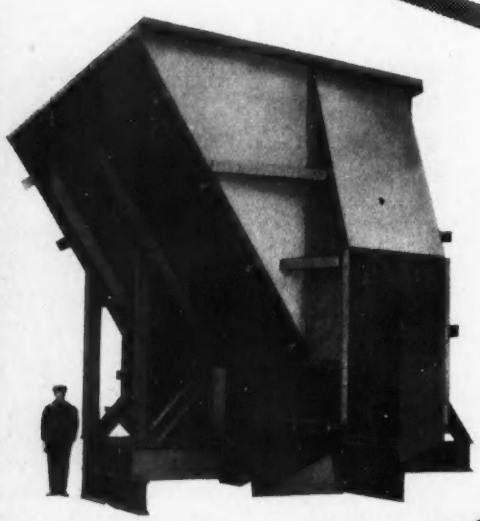


4-way Branch Pipe Unit of all-welded Steel Fabrication.



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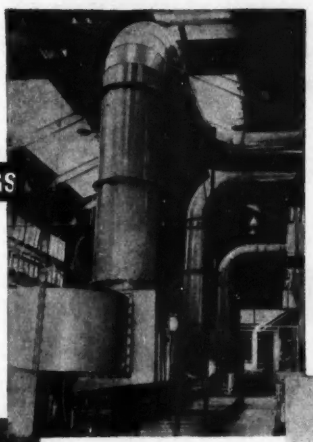

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Leading from the anodising tanks at the Vickers Supermarine Works, South Marston, this exhaust ducting is made in COBEX by Horwitch Smith and Co. Ltd.

THE PROOF is in the organisations using it. The list is a long and impressive one. The following are just a few of the many world famous industrial companies which choose COBEX for important work involving corrosion resistance.

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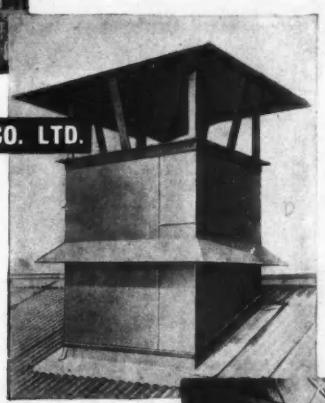

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Cowl on the ducting system constructed entirely from COBEX in the Barry (Glamorgan) works of British Geon Ltd., a Distillers plastics company. Fabricated by Tanks & Linings Ltd., Droitwich

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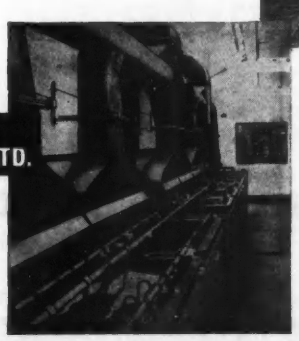

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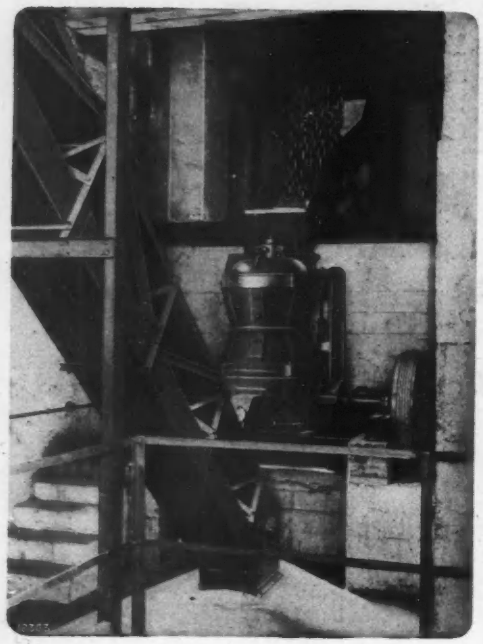

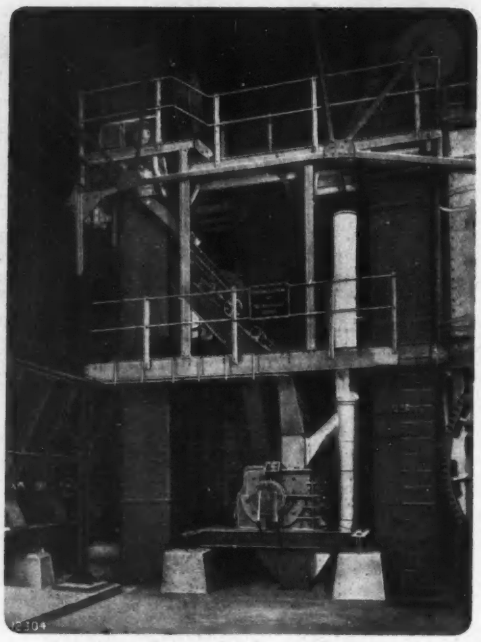

Left: Sturtevant Rotary Fine Crushers are suitable for the primary reduction of soft and moderately hard materials giving a product between ¼" and 1". They are made in six sizes having capacities of 1 cwt. to 25 tons per hour.

Right: Sturtevant Hammer Mills will treat a wide range of materials—soft, moderately hard and tough or fibrous substances to any degree of fineness between 1 inch and 20 mesh. Four sizes are made having capacities of 5 cwt. to 15 tons per hour.

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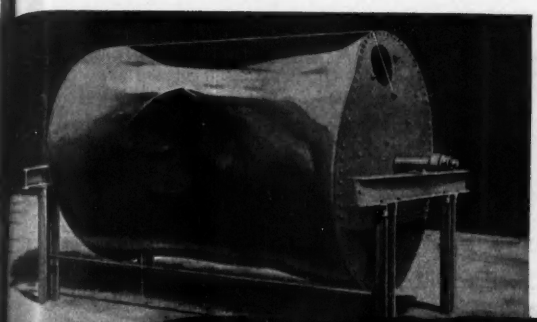

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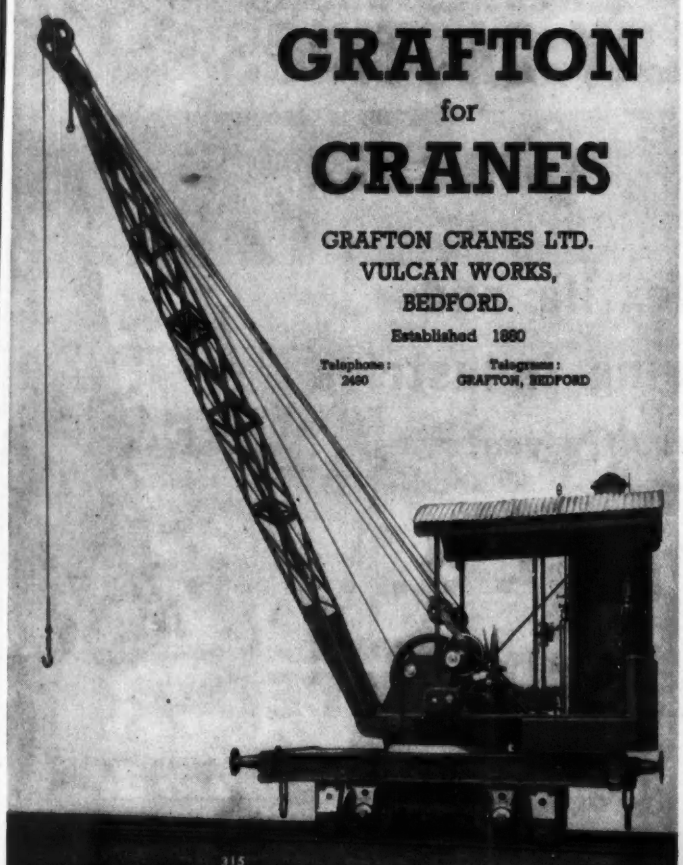

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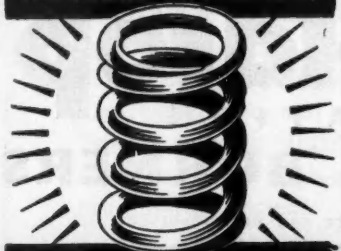

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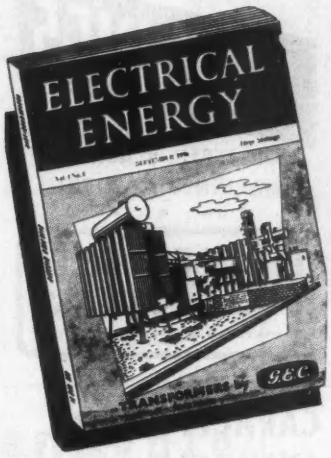

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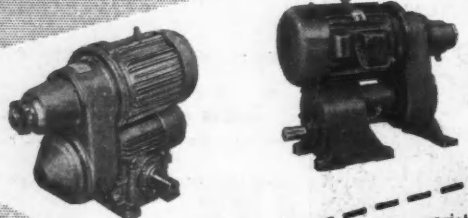

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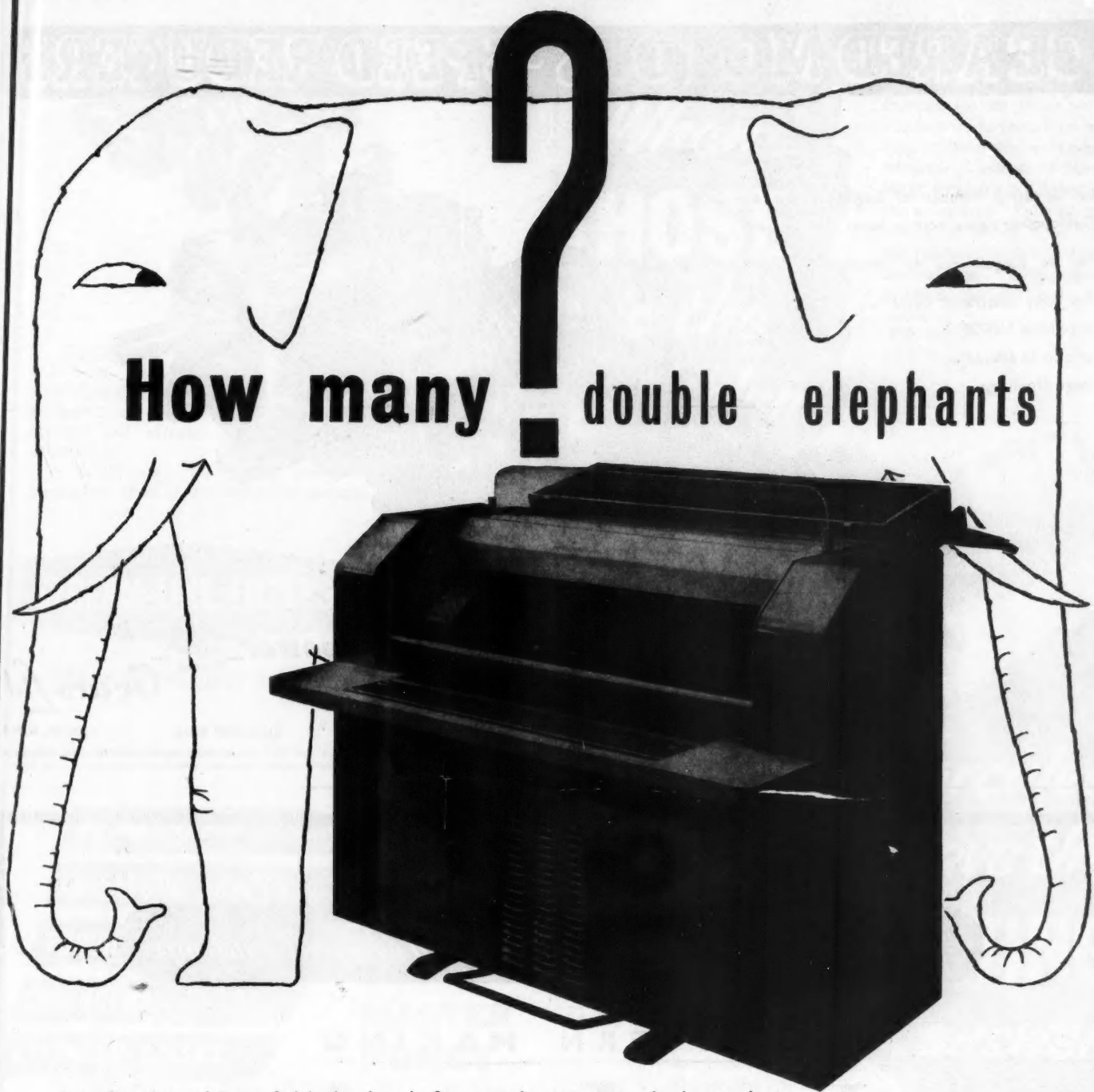

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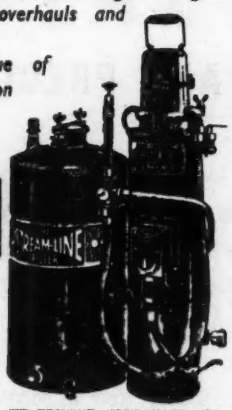

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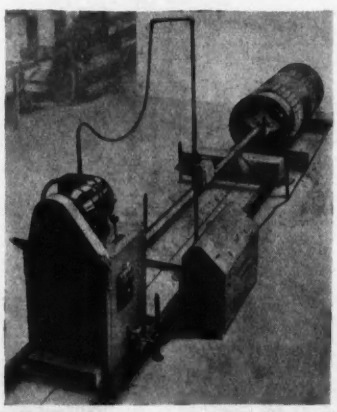

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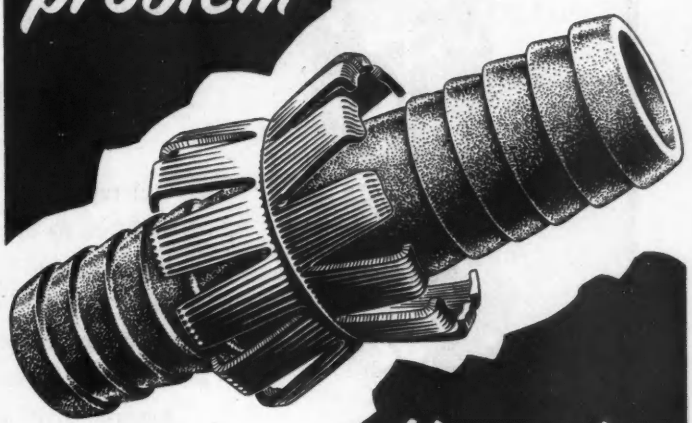

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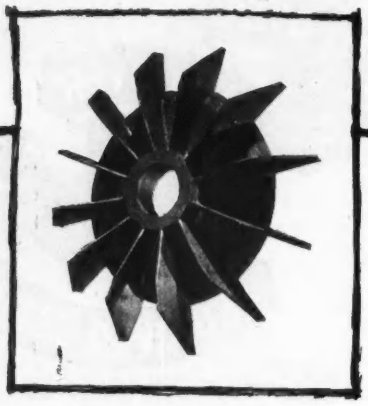

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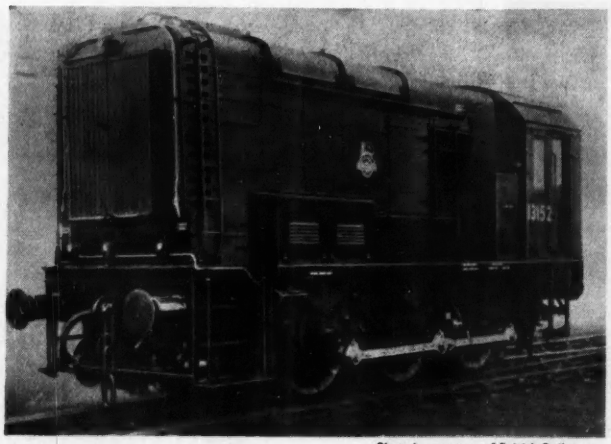

Photo by courtesy of British Railways.

One of British Railways Diesel Electric Shunting Locomotives equipped with Lister Blackstone 350 b.h.p. Diesel Power Unit.

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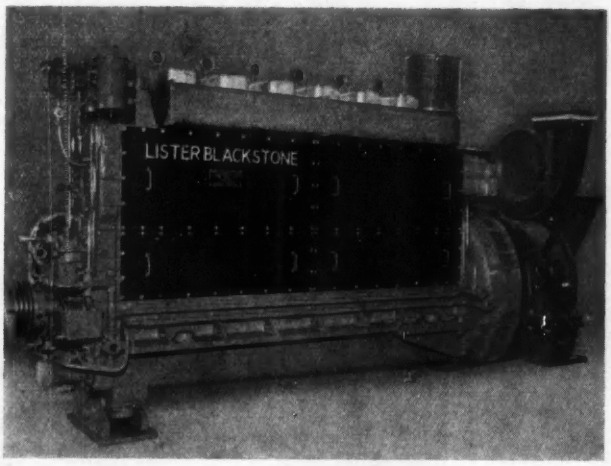

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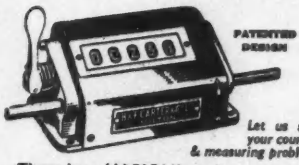

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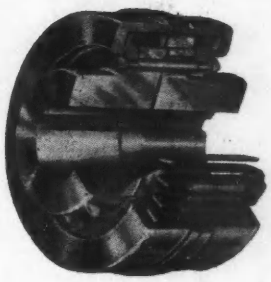

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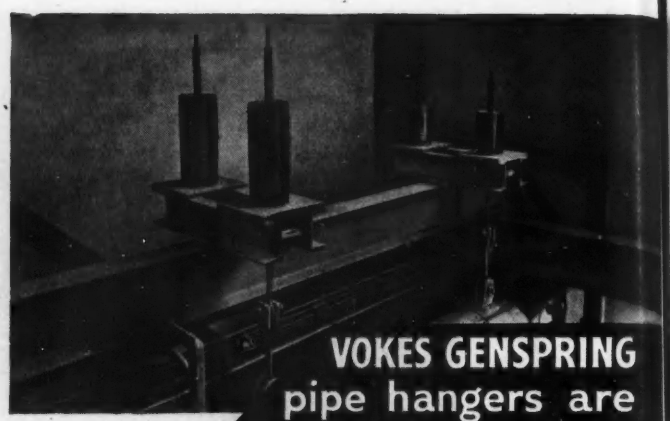
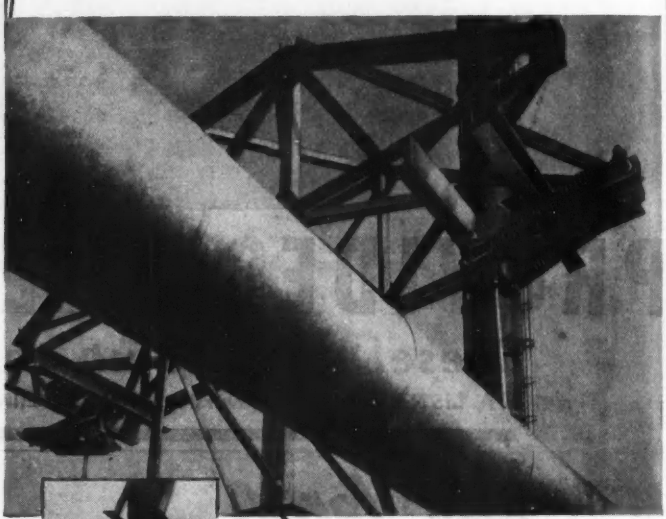


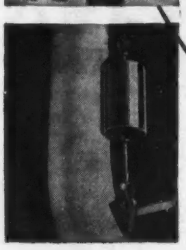
Photograph by courtesy of The Associated Ethyl Company Limited.

VOKES GENSPRING pipe hangers are used throughout the oil industry

At their Ellesmere Port Works in Cheshire, The Associated Ethyl Company Limited have made use of VOKES GENSPRING Variable Support Pipe Hangers to control movement which could set up very great stresses in the piping. 'Shell' have also incorporated VOKES GENSPRING hangers throughout the Platforming Unit at their Stanlow Refinery in Cheshire.



Photograph by courtesy of 'Shell'.



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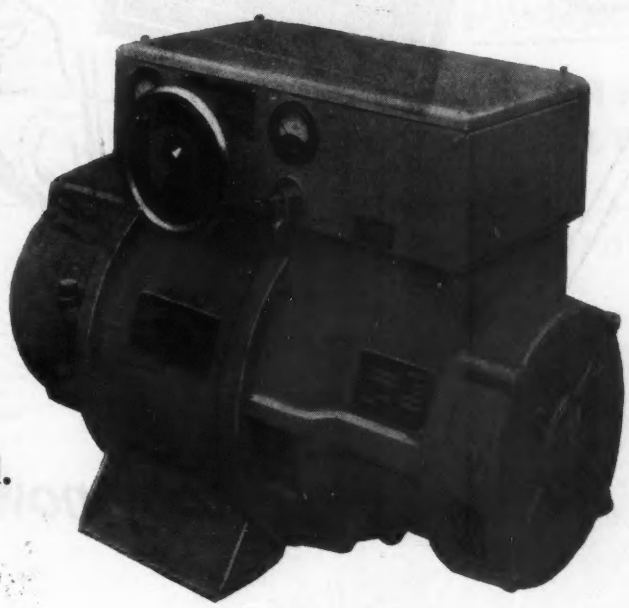

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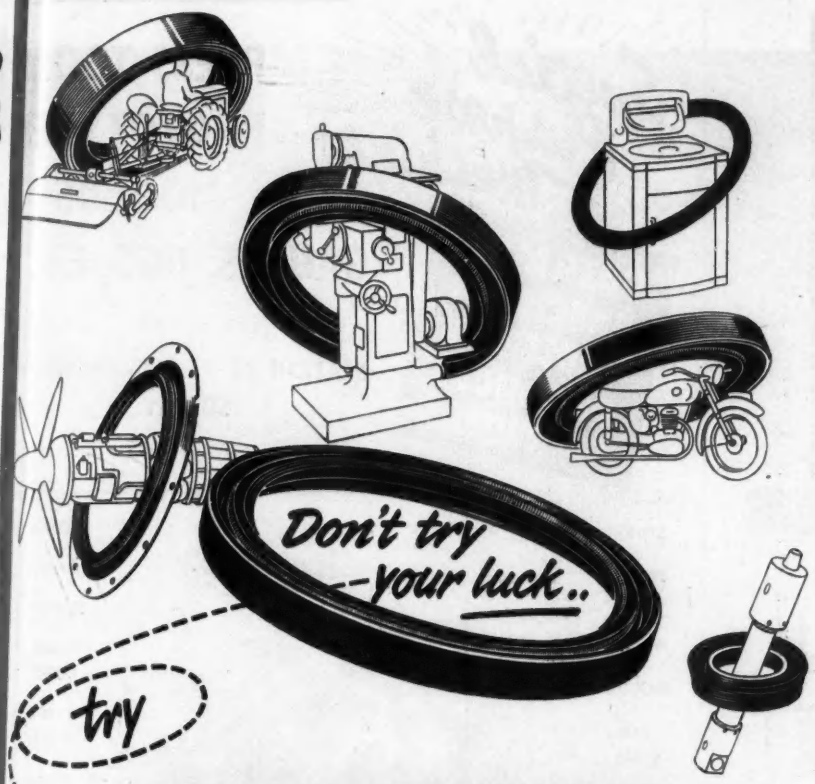

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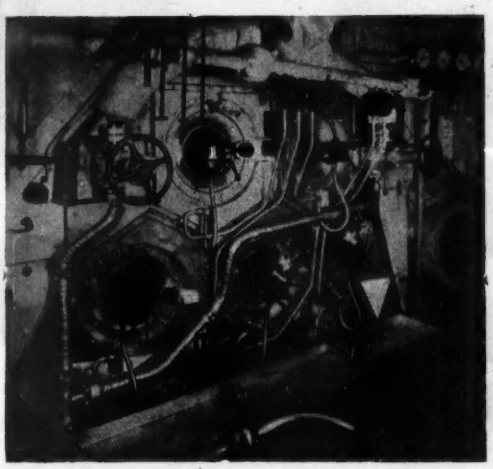

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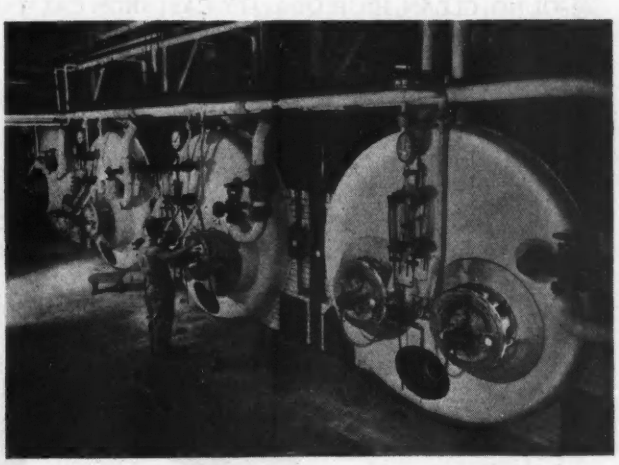

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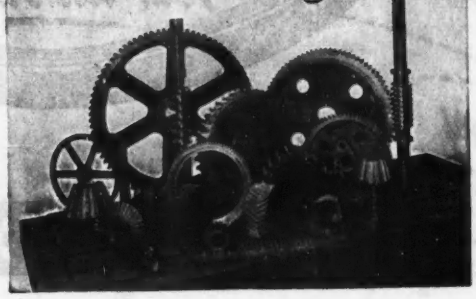

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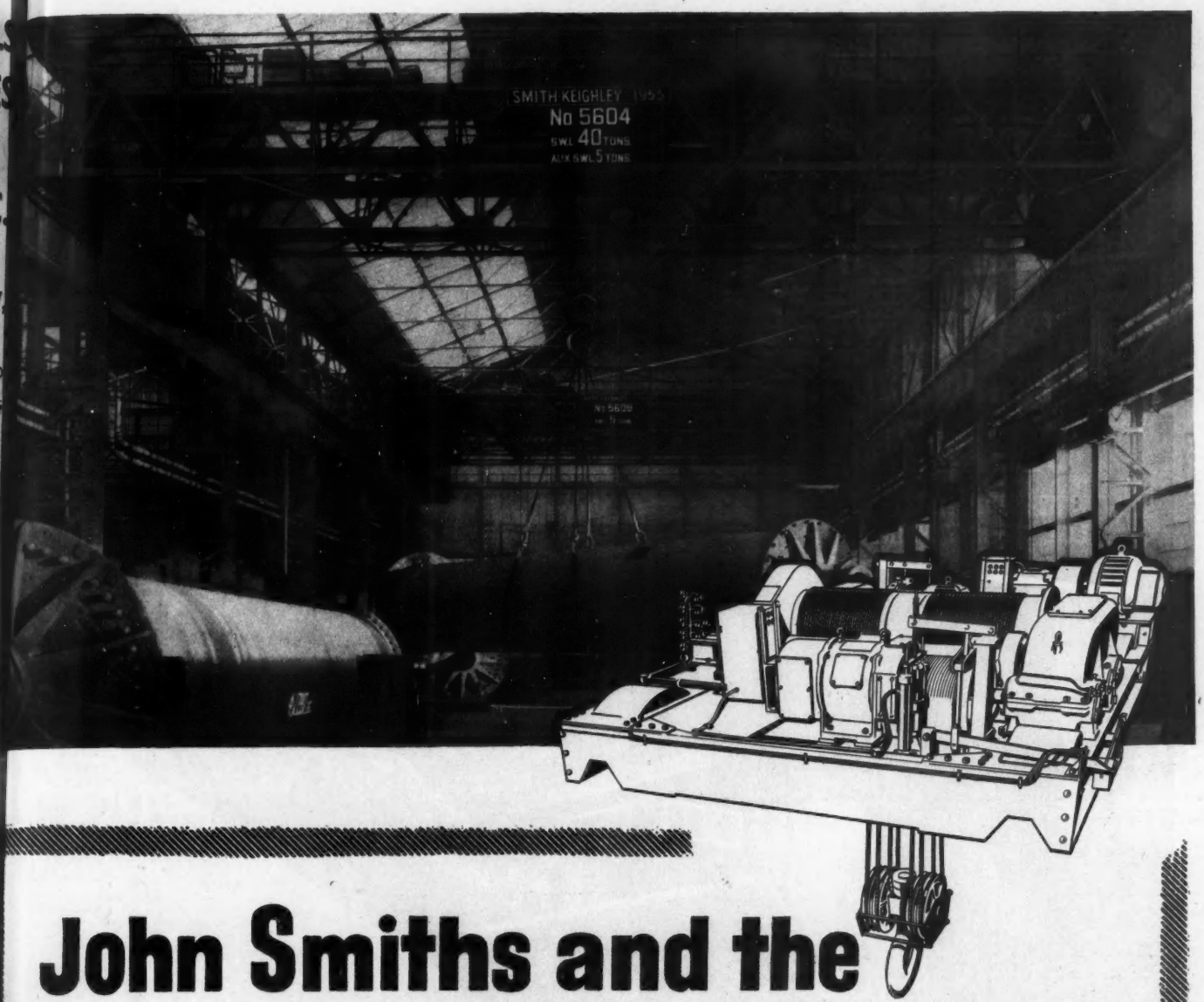

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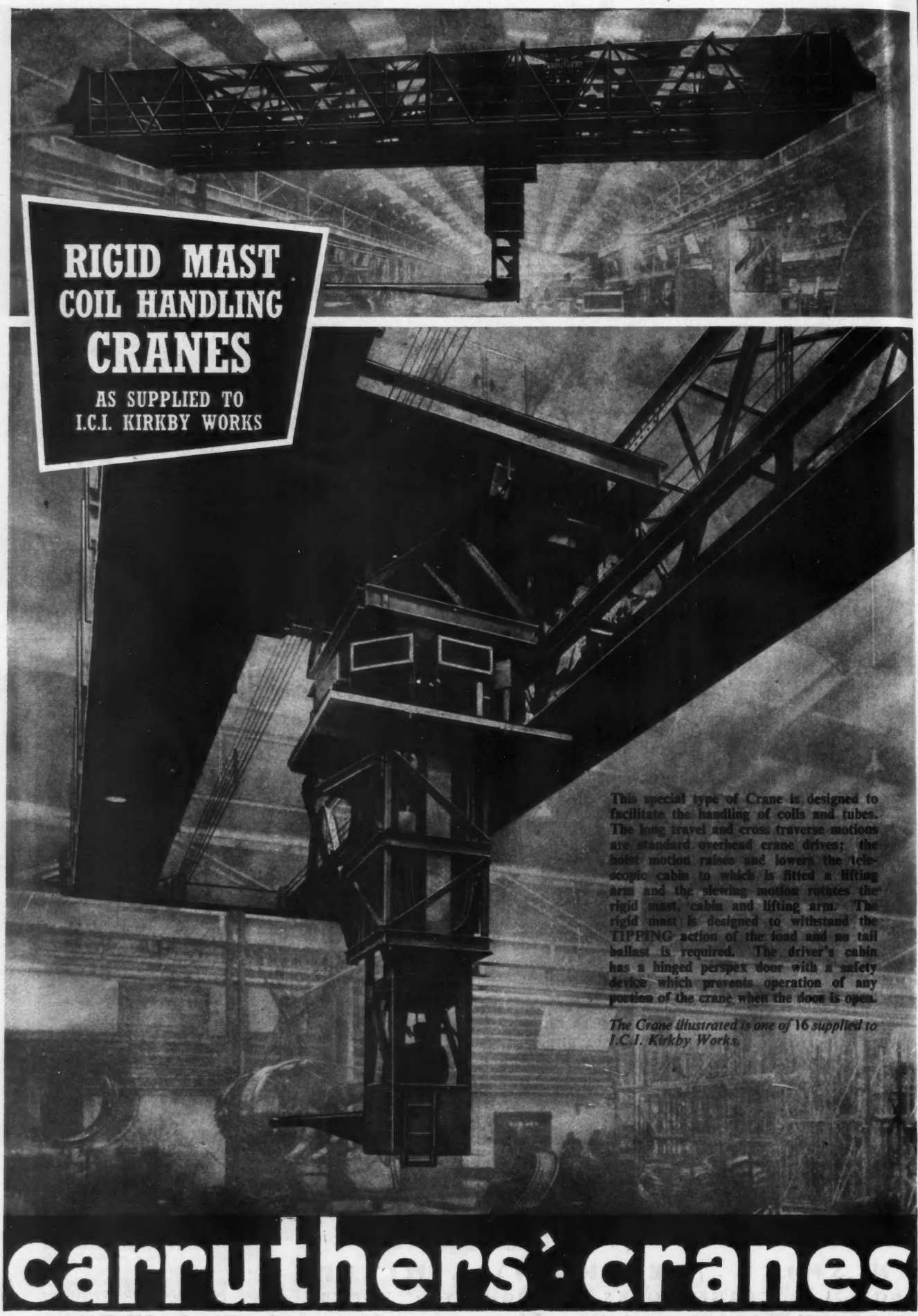

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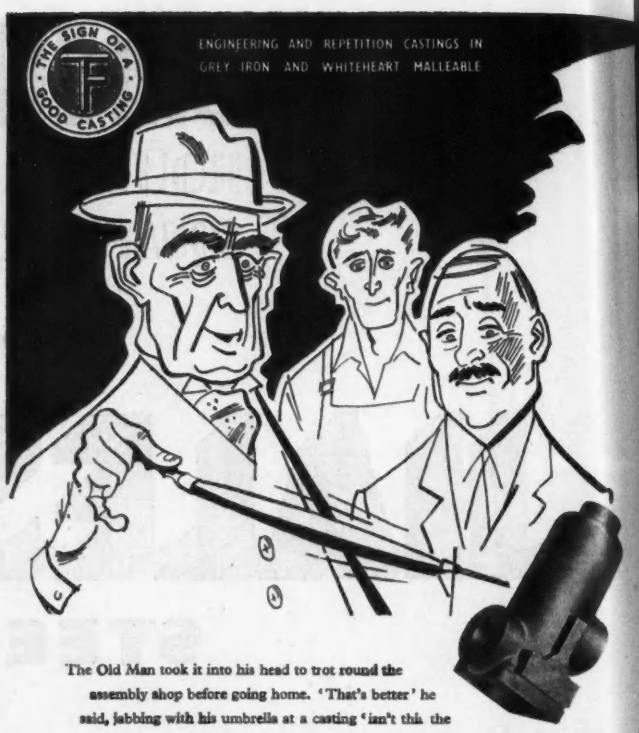

The Old Man took it into his head to trot round the assembly shop before going home. 'That's better' he said, jabbing with his umbrella at a casting 'isn't this the bench where I saw that nasty bit of iron, last month?' 'Yes' said Jim going a bit pink 'but we've changed our foundry since then.' 'I should hope so' said the Old Man 'can't expect you chaps to make a silk purse out of a sow's ear. Who's making your castings now?' 'Triplex' grinned Jim. 'Good, good' said the Old Man 'now I expect some silk purses' and then - - -

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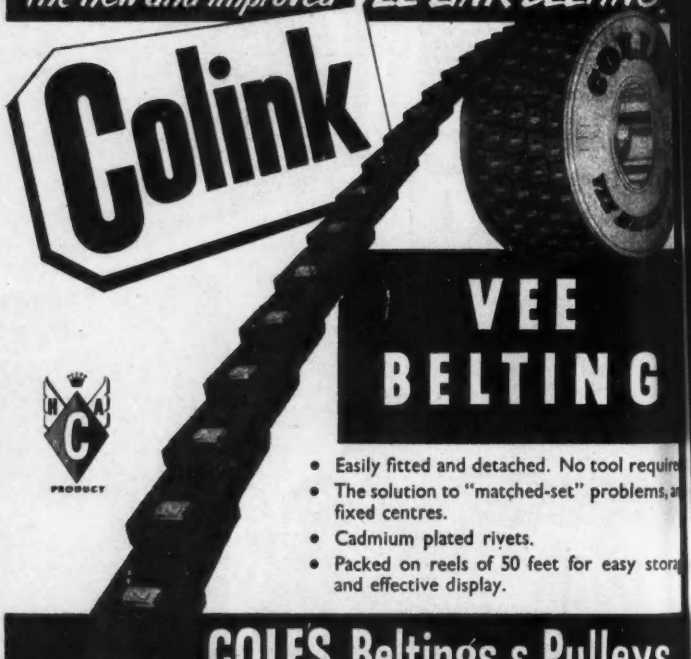

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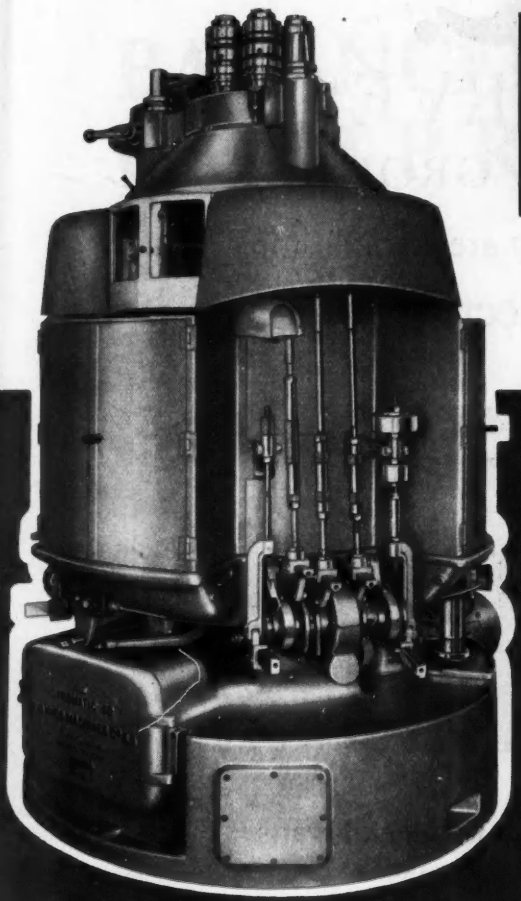

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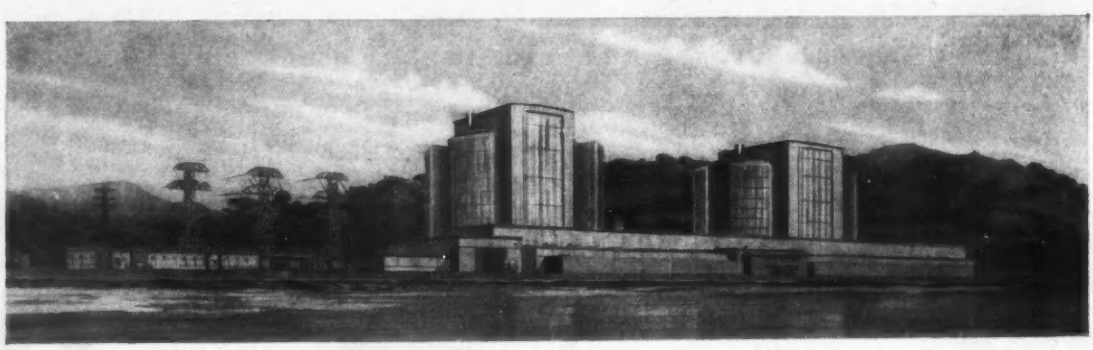

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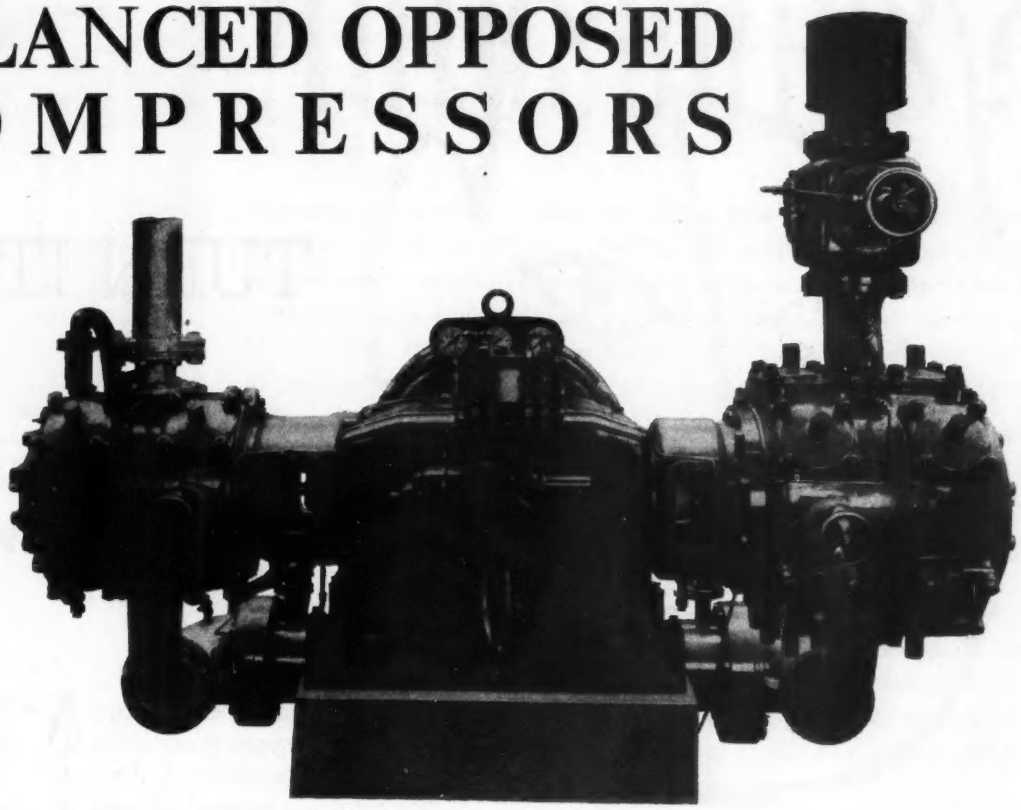

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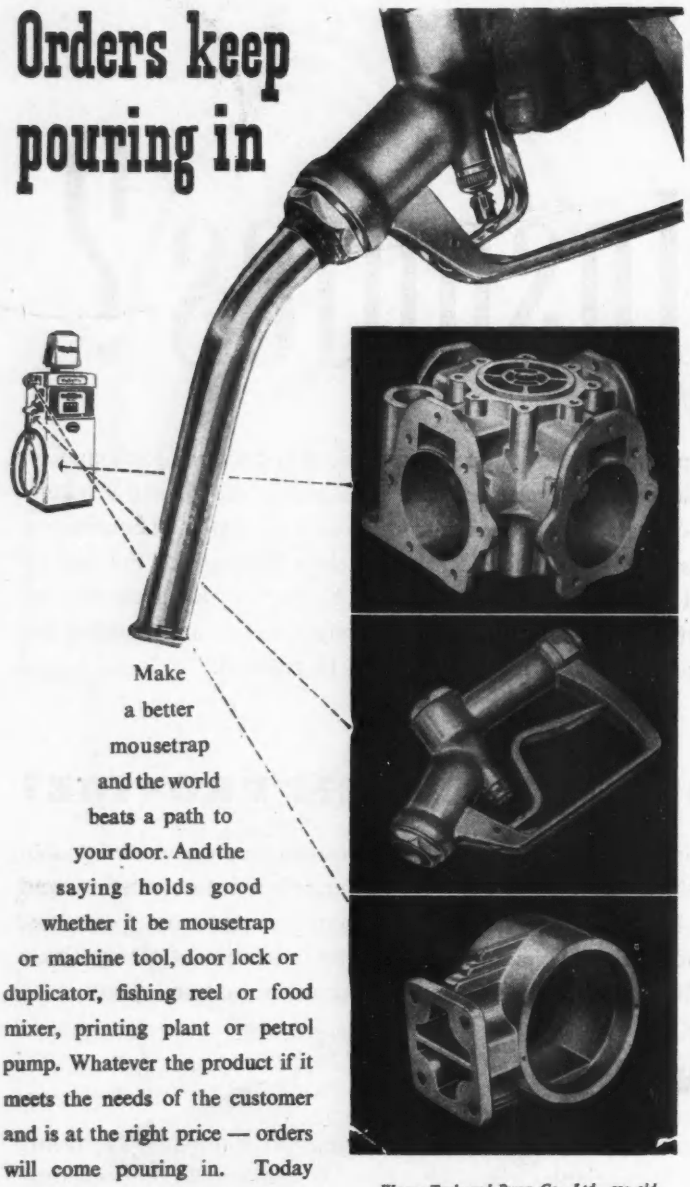

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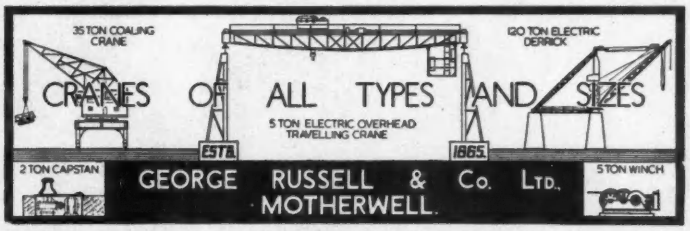

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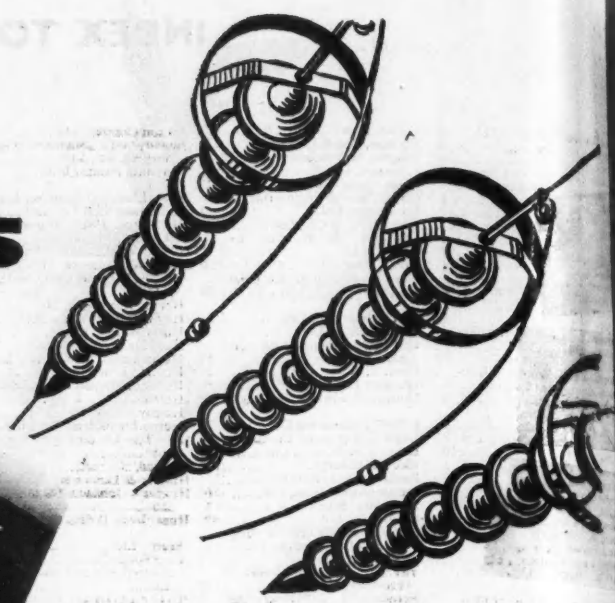

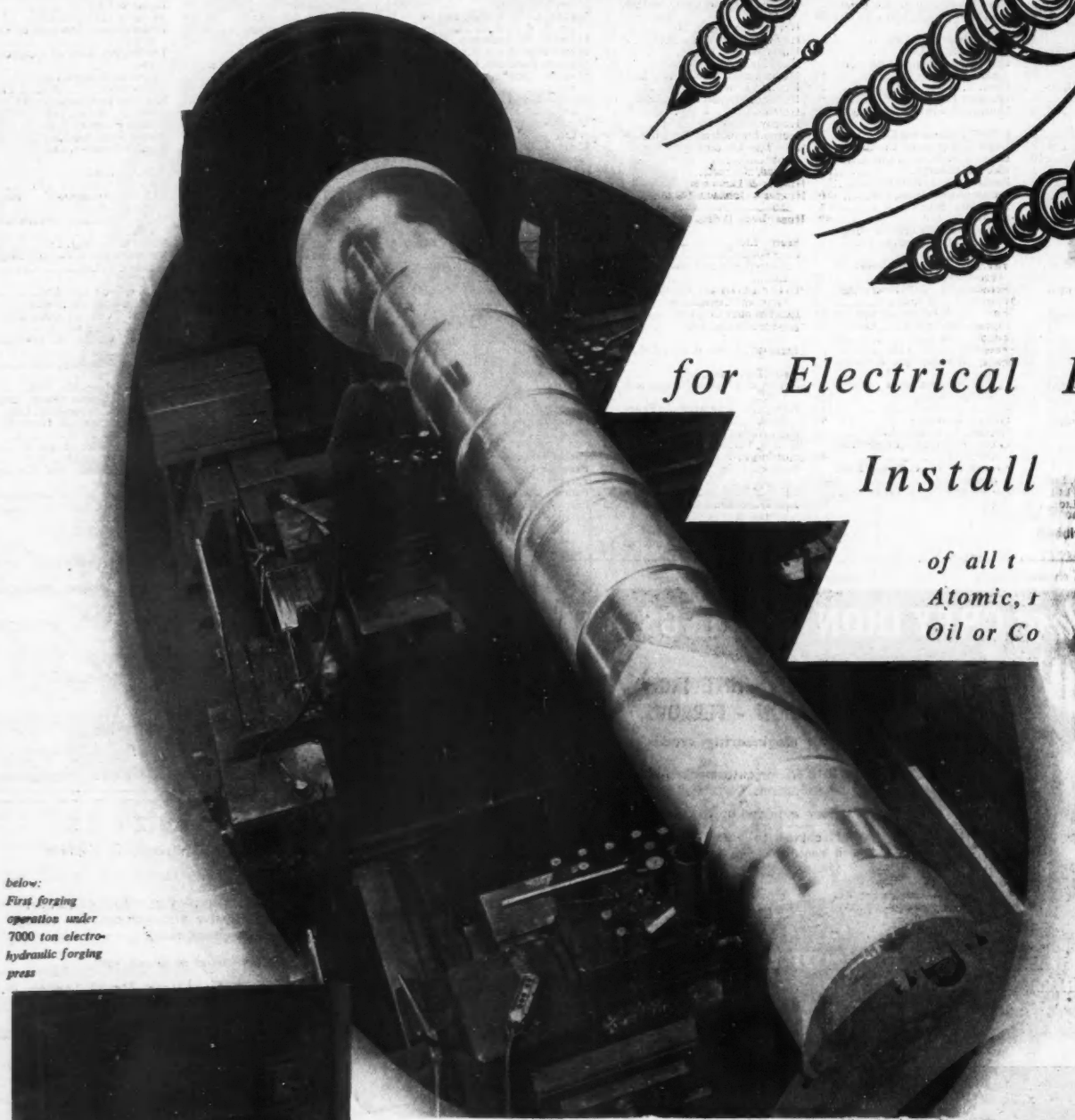

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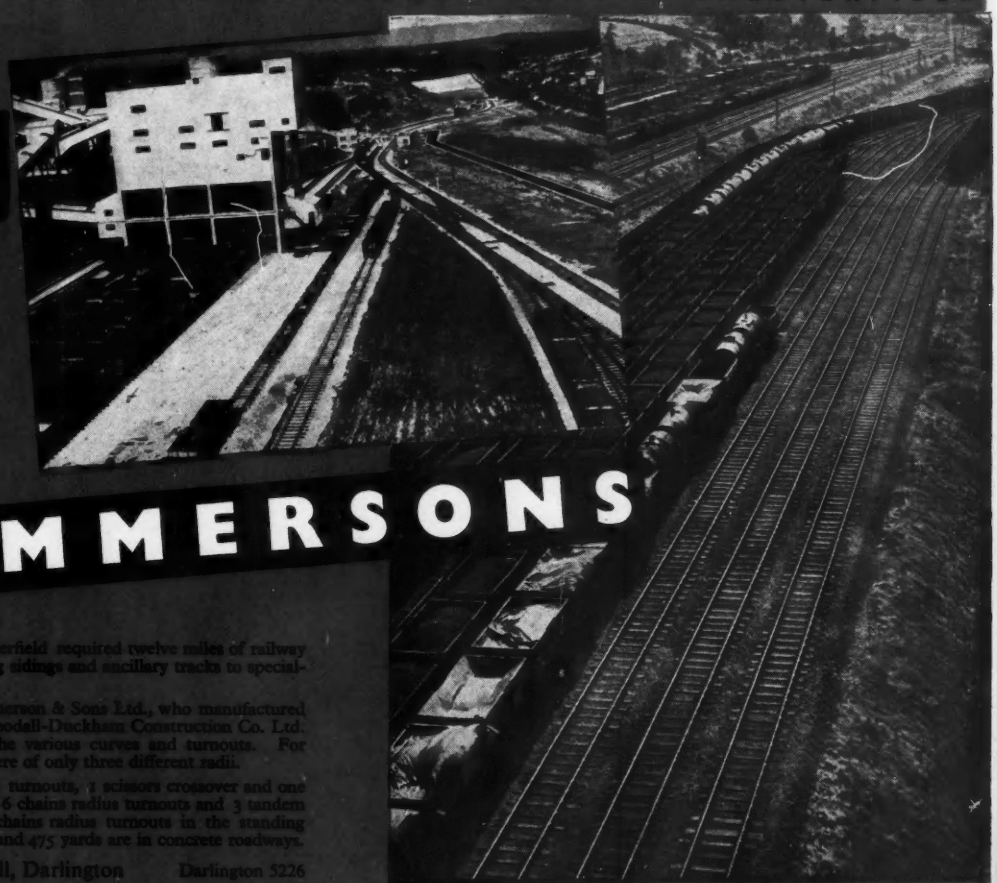

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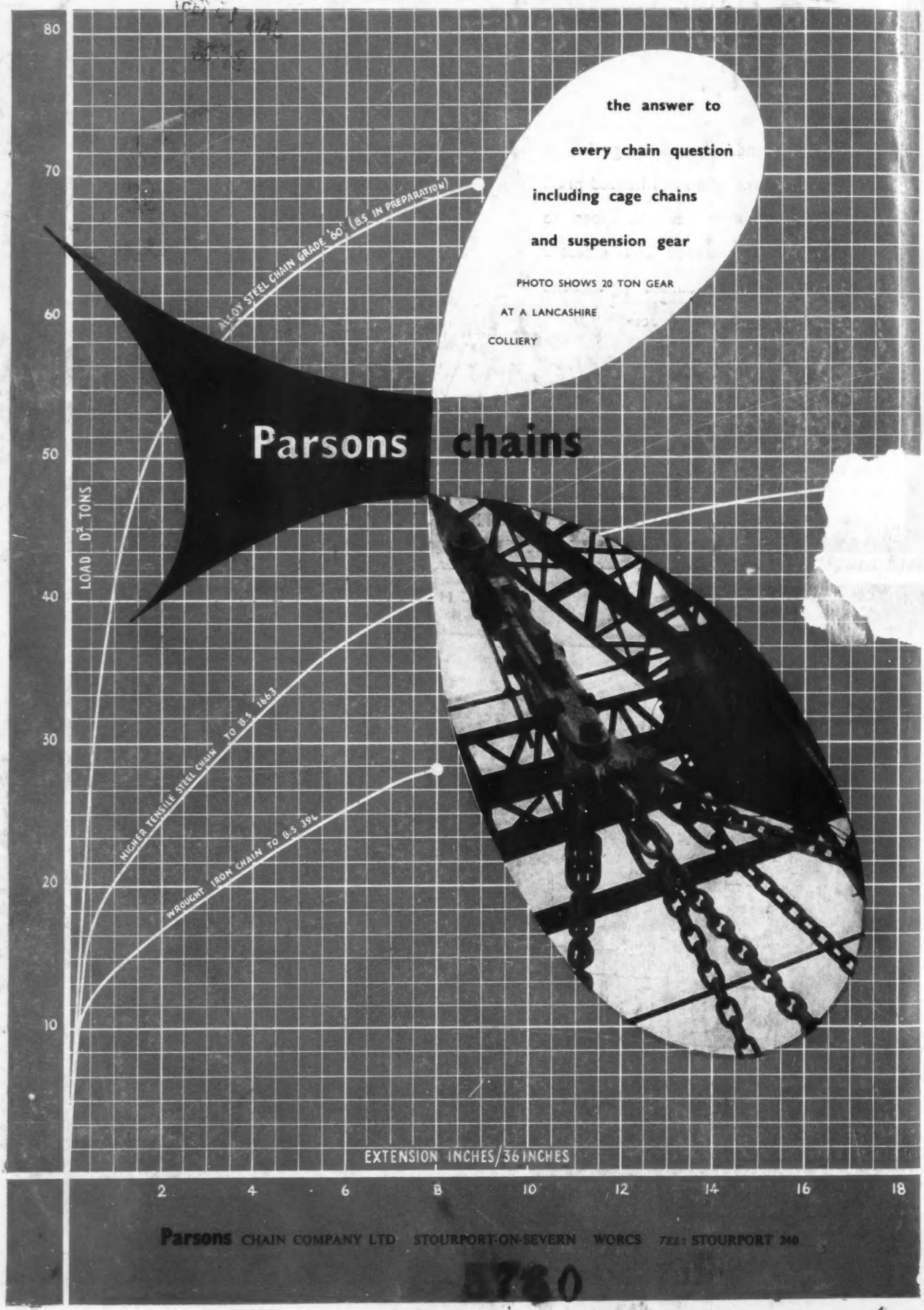
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